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## EDITORIAL

### SURGERY OF THE EXTREMITIES

FOR locomotion, prehension and much of sensory appreciation, we depend on our extremities. The mechanical phases of surgery in this field are largely the concern of the orthopedist. The newer speciality of industrial surgery is utilitarian. It considers disability of the employed workman in the light of his earning capacity. The period of disability and ability to keep on the job are considered more important than cosmetic result. A hand that will enable a man to work, even though unsightly and shorn of some of its digits, may be preferable to an intact member with impaired function. Thus, the surgery of the extremities is often to be adapted to the individual and to his mode of life.

Unfortunately many injuries of the extremities are yet treated by those with little surgical experience. Fortunately, however, the intern no longer takes pride in the number of amputations he has done during his dispensary service. The importance of conserving the hand and its parts seems much more widely appreciated than formerly. Many apparently hopelessly crushed limbs recover in quite an amazing way if secondary skin tension is prevented by immediate long volar and dorsal incisions through the skin. Instead of closing the badly contused wound with sutures, it is better to lay it widely open. A common mistake was to suture meticulously the various divided structures, whereby the limited remaining vitality as well as the resistance to gas bacillus or other infection was lost through the manipulation, or strangled by the secondary swelling and tension of the skin. By delay and with the part living and revitalized, the suture of the divided nerves, tendons and the like may be done with relative safety. A second mistake was to do a primary amputation without waiting to determine viability; or to sacrifice an important part of the hand or foot to obtain skin flaps, instead of depending upon the later transfer of pedicled

## Editorial

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flaps or full thickness skin grafts from another part of the body.

With infections of the extremities, as of other parts, it is well to bear in mind the two great clinical types of infection. In the first, early operation kills; in the second, delay in operating may be fatal. In streptococcal infections the onset tends to occur within a few hours after inoculation, the general reaction is severe and the marked local serous edema is often mistaken for suppuration. Ill-timed incisions and manipulations in such cases often lead to a fatal blood stream infection. For anthrax also the older aggressive local treatment with scalpel, cautery and injections of antiseptics had a mortality of about 40 per cent. With complete rest, local protection and immobilization, the mortality has fallen to about 5 per cent. Staphylococcal infections, on the contrary, are associated with a surrounding and isolating zone of vascular thrombi which is protective. There is, as a rule, little danger of a fatal bacteremia, and an early venting of the pus is desirable. Staphylococci commonly infect the skin or bone, but it is to be remembered that the osteomyelitis of infancy differs from the more common form of childhood and later life, in being streptococcal and, like the empyema or other infections of similar cause has the lowest mortality when operation is delayed. A staphylococcal osteomyelitis may be aborted very early merely by drilling the overlying skin and bone in a number of places with an ordinary gimlet as suggested by John B. Murphy. Extensive destruction of bone and increased mortality follow delay in operating. Even more

urgent is early operation in gas gangrene, and it is a good rule, where hemorrhage is not a factor, to consider every case of prolonged or secondary shock after trauma of an extremity, as due to gas gangrene until the possibility of this infection has been excluded.

By remembering that lymphangitis and lymphadenitis commonly have a portal of entry in the distant tributary lymph fields a puzzling infection may often be solved. With a patient seen recently, for three years in the dead of winter and in the middle of the night a mysterious red painful swelling suddenly involved the calf of the leg, to incapacitate him for three months or more. For another somewhat similar condition sulfanilamide had been given for four months. In each case the mystery was dispelled by looking between the toes. The first patient considered himself cured within twenty-four hours after he had used a permanganate foot bath for the dermatomycosis. Quite different was a pale, pulseless, extremely painful leg that had shown only a few weeks of improvement after arterial sympathectomies under two surgeons. At consultation a high amputation was advised, but it was finally shown that it was the complete bed rest that had given the relief after the two operations and with this as a guide the patient retained his leg and lived quite comfortably a number of years until the inadequate heart finally gave out. Thus the dermatologist and cardiologist are among those who may aid the surgeon in treating certain affections of the extremities.

W. WAYNE BABCOCK.

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# ORIGINAL ARTICLES

## VARIETIES OF THROMBOPHLEBITIS OF THE LIMBS THEIR ORIGIN, COURSE AND TREATMENT

JOHN HOMANS, M.D.  
BOSTON, MASSACHUSETTS

ANY account of the known varieties of thrombophlebitis would be incomplete without some explanation of the influences which cause them to arise. For the purposes of the subsequent descriptions, the brief statements made under the following headings (some of which may be disputed) will be held to be significant:

1. *Retardation of the Venous Return.* This is probably of the first importance. It comes about most naturally during life in bed. The general circulation may be feeble because of heart failure and serious debilitating diseases; or, following operation or injury, because of the increased abdominal pressure of tight dressings and intestinal distention; or, because of a reclining position in bed, the body being raised and the legs relaxed (loss of muscular effort in forwarding venous blood toward the heart); or, during active life, because of abdominal adiposity or excessive abdominal tension; or, because the veins of the legs are exposed to unnatural congestion, momentary or otherwise.

2. *Anatomic Relations in the Veins of the Limbs.* The areas in the lower half of the body especially liable to thrombosis are shown in Figure 1. The left common iliac vein passes at a right angle under the right common iliac artery, thereby exposing its stream to especial retardation. Each external iliac vein passes behind a hypogastric artery. There are many entering veins causing confused currents in the region of the inguinal ligament and in the upper calf and popliteal space. These and the large valves in this area combine to make eddies

in which the thrombocyte (the active villain in thrombosis) tends to settle and adhere.

3. *Changes in the Blood, including Dehydration.* These relate chiefly to the factors which favor or oppose coagulation and are the subjects of Bancroft's "clotting index." The blood may be affected by diet and drugs, and may be dehydrated by bleeding, vomiting or excessive sweating, whether at the operating table or during an illness. Such influences, especially the dehydrating factors, tend to be preventable and remediable.

4. *Trauma.* This is a mysterious influence which I have elsewhere called the "X" factor. It seems often to touch off the thrombosis when the background is favorable. It may take the form of a minor accident or serious fracture, childbirth or an abdominal operation. That it acts promptly is to be inferred from the accepted tendency today to commence precautions against thrombosis immediately after surgical operations, not some days later. Thromboses are apt to arise upon the same side as the injury, even though the fracture, if such has occurred, lies well away from the thrombosed vein. There is sometimes a suggestion of allergy about the influence of trauma.

5. *Perivascular Inflammation.* This factor is as yet little understood. Explorations by various investigators have shown that in many but not all instances of femoroiliac thrombophlebitis there is a non-suppurative, very vascular exudate about the thrombosed vein and the companion ar-

## Homans—Thrombophlebitis

tery, that is, about the arteriovenous bundle including the lymphatics. The origin of this is obscure, but that it is not uncommon can be implied from the arterial spasms both immediate and late which occasionally complicate phlegmasia alba dolens (femoroiliac thrombosis). That is to say, something evidently irritates the wall of the great vein and artery producing thrombosis in the former and a state of spasm in the latter. The condition of the thrombus itself can hardly account for such inflammation, which seems a primary, not a secondary phenomenon. Nevertheless, as already stated, it is not always present, nor is arterial spasm often demonstrable.

6. The plexuses of veins draining respectively the uterus and prostate are undoubtedly the scene of thrombosis, but as yet there is no known detectable symptom-complex. If the thrombosis which is thought to occur in these veins gives rise to embolism, the matter must be of great importance.

7. Outspoken thrombosis seldom causes pulmonary embolism. Quiet and actually symptomless processes are very apt to do so. The matter is related to the reaction in the vein's wall. Thrombosis in varicose veins, for instance, the walls of which are obviously diseased, almost never causes embolism, and phlegmasia alba dolens, when attended by swelling and fever, does so relatively seldom. By contrast, the unnoticed thromboses often cause embolism. It must be supposed that the less secure or inflamed the vein's wall the less secure the thrombus and the more frequent the embolism.

8. The propagating thrombus, the cause of embolism, is most apt to form an association with quiet thrombosis and in a slow stream. It represents a soft, friable, floating clot so attached that it waves in the current of an entering vein proximal to the thrombus or grows into the open principal vein from a thrombosed branch. Small and short detached clots cause pulmonary infarction. Large ones cause fatal pulmonary

embolism. Most fatal ones are 10. to 12 inches long or are composed of many short thick fragments.

## VARIETIES OF THROMBOPHLEBITIS

*Phlegmasia Alba Dolens: Femoroiliac Thrombophlebitis or Milk Leg.* This is the common "phlebitis" of the laity, the cause of the great white swollen leg—usually an outspoken disease, sometimes painful, especially at its onset. Its scene is the principal vein draining the leg in the region of the groin. It leads to embolism in a rather small proportion of cases, yet the total number of femoroiliac thromboses is so great that it is in fact a fairly common cause of pulmonary embolism.

Though instances of femoroiliac thromboses occurring during active life have been collected by Barker, the disease usually attacks those who, for one reason or another, are confined to bed. The vein involved are the upper femoral, the external and perhaps the common iliac. Slowing of the stream and the eddies and cross currents already described are certainly factors in causing this disease. Aschoff remarks that when both sides are affected the process is likely to extend, on the left, through the common iliac vein and ligament. However, the process often stops cleanly on either side at the point where the external iliac vein passes behind the hypogastric.

Phlegmasia alba dolens is particularly apt to follow operation or injury in persons in or beyond middle life. However, it occurs so frequently in young women after childbirth and often enough in young adults of either sex after acute fevers or such a simple operation as appendicectomy, as to make any categorical statement about a particular age incidence absurd. It would be better to say that a femoroiliac thrombosis comes especially to mind when any sort of operation is proposed for an individual of 55 years or over. After an operation upon the prostate or hysterectomy for

fibroids it is perhaps twice as frequent as after upper abdominal procedures. Surgeons are apt to forget how very often a combining to offer an ideal background for the disease. Reasons have already been given for believing that the initial throm-

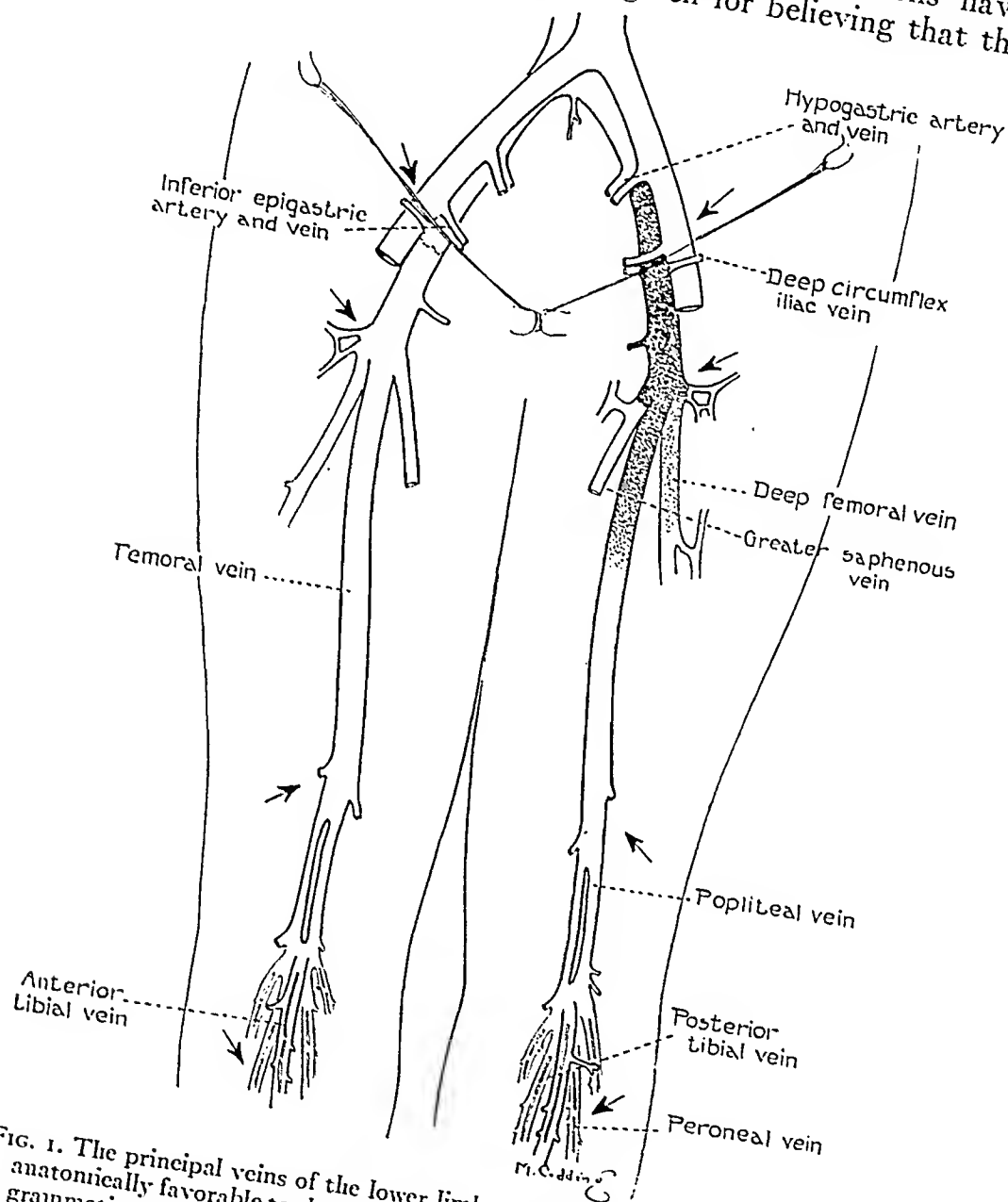


FIG. 1. The principal veins of the lower limbs. Arrows point to the situations anatomically favorable to the formation of a thrombus. On the right is a diagrammatic representation of a left-sided femoroiliac thrombophlebitis. The process ends cleanly (proximally) beneath the hypogastric artery. The distal end of the thrombus is left intentionally vague. The process is shown as not invading extensively the entering branches which are able to carry on a collateral circulation. Variations upon such an arrangement can be imagined.

phlegmasia alba dolens is associated with debilitating conditions—not only the serious, acute fevers like pneumonia and typhoid, but circulatory failures and advanced organic diseases of any sort. Fractures of the lower limbs occasionally bring it on, the injury, plus immobilization of the leg, plus the reclining position so often used

basis usually starts very promptly after favorable conditions for its establishment have occurred. How soon it shows itself thereafter seems to depend upon developments little understood.

When a whole lower limb is swollen, it is certain that a femoroiliac thrombophlebitis is present, but absence of edema



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is no proof that the disease does not exist. The amount of edema seems to depend upon the extent of the process, the efficiency of the collateral circulation, and the degree to which the deep lymphatics are obstructed. Naturally a very extensive thrombosis makes the prompt establishment of a collateral circulation a difficult matter, whereas a local one is easily circumvented. Insidious onset and development are consistent with an absence of edema. By contrast, a very acute, active process will cause the limb to swell so tensely, within a period of seventy-two hours, that it will not pit on pressure and is utterly unwieldy. A leg of this sort is not cyanotic and, though a sufficiently widespread thrombosis is perfectly capable, by itself, of causing an advanced edema, one cannot help thinking that lymphatic obstruction is very much concerned with the swelling. Paine looks upon an almost pure lymphedema as being exceedingly common. The writer, though recognizing the perivascular inflammation which Cruveilhier, Leriche and he have demonstrated in their several ways, to be a probable cause of lymphedema, is aware that a very full swelling of a limb can be present without any perivascular involvement of the lymphatics whatever. This de Takats has experimentally proved.

The onset of phlegmasia alba dolens is more often than not ushered in by pain, sometimes of such severity as to suggest acute arterial ischemia. The pain is referred to the groin, the inner face of the thigh, even to the back of the knee or calf. With this there is apt to be some degree of soreness over the upper femoral region and sometimes above the inguinal ligament; but the swelling may appear insidiously, without pain or at the most with a feeling of numbness or heaviness. As a rule, the pain is preceded for twenty-four hours by a moderate elevation of pulse and some rise of temperature. It is not followed by swelling for perhaps another day. Then edema mounts rapidly from the ankle to the groin.

The peripheral arterial pulse in the affected extremity is sometimes decidedly weakened. It may even disappear, in which case the leg becomes cold, bloodless and presents the appearance associated with arterial embolism or thrombosis. Many instances have now been recorded, notably in the French literature (Audier), of arterial spasm on the grand scale, so serious as to result in gangrene of the limb. Indeed, explorations have actually been known to disclose a shrunken femoral artery, lying beside a thrombosed vein (Gregoire). Leriche, who has always stressed the vasomotor disorders of thrombophlebitis as a cause of discomfort and edema, has gone so far as to treat the early stages of femoroiliac thrombophlebitis by daily injections of procaine into the lumbar sympathetic chain which supplies the diseased leg. By securing a vasodilatation in this way, vascular spasm is thought to be reduced, the discomfort lessened and the circulation improved.

The idea of a vascular spasm, venous per-haps as well as arterial, is consistent with the observed after-effect of occasional instances of phlegmasia alba dolens. I am beginning to see more and more often individuals suffering from obvious chronic vasomotor spasm following phlegmasia alba dolens. Their legs are a little cyanotic, a little edematous and rarely hypersensitive and painful. That is, a state somewhat resembling reflex edema, reflex dystrophy or causalgia occasionally develops—a vicious circle undoubtedly related to the perivascular inflammation at the scene of the original thrombosis. Postphlebotic indurations and ulcers, not directly related to stasis in the veins themselves, are of course common and may be of a somewhat similar origin.

The course of a femoroiliac thrombophlebitis is extraordinarily variable. A mild form causes only a moderate swelling which disappears after ten days or so and leads to almost no residual edema when the patient first gets about. A severe form, associated with fever and both local and

general discomfort, results in a huge, hard limb which changes little over many weeks or even months. When at last the swelling goes down, the patient is sometimes left with a limb larger than its mate and subject throughout life to some degree of edema, especially of the ankle and lower leg. Once a femoroiliac thrombosis is established, some individuals seem to become increasingly thrombophilic. The opposite leg is involved far more often than is generally supposed, but perhaps so quietly and with so little swelling that the second process is overlooked. Occasionally a thrombophlebitis passes back and forth from one leg to another, recurring later in the one first attacked.

The appearance of the leg is usually one of white swelling. There may be a faintly cyanotic color, as if there were present a generalized peripheral vasoconstriction. Veins are rarely visible, but as the swelling goes down, large, seemingly collateral vessels sometimes appear in the upper thigh, the pubic region and the lower abdomen, remaining throughout life. Occasionally, the great saphenous vein can vaguely be felt as a tender thrombosed cord which later becomes varicose. Far more often, tenderness over the upper femoral canal gives rise to the suspicion of a superficial thrombophlebitis which, in fact, does not exist. The leg is not noticeably hot or cool. Only very occasionally are any lymphatic streaks to be seen.

The aftermath of a phlegmasia alba dolens is usually far less disabling than might be supposed. It is inconceivable, of course, that any valves involved in thrombosis can again function normally, yet very few feet are left cyanotic after the upright position is resumed. The ankle may be puffy but the toes are not blue. Only occasionally, large veins are left which in time become varicose. The probability is that the worst of the thrombosis takes place in the external iliac, where only one valve is occasionally present, and in the upper femoral where after all only a few are lost. Collateral vessels help out

and the deep veins of the lower leg are seldom involved. The real difficulty is with the perivascular and superficial tissues, as has already been told.

*Preventive Treatment.* Certain influences favoring thrombosis are unavoidable: in particular, the anatomic and physiologic peculiarities of the venous return from the legs, the exciting traumatic factor, debilitating disease and, of course, life in bed. To these are added the more or less avoidable influences of dependency and immobilization of the lower limbs, increased abdominal tension and dehydration. The first set can be minimized; the second, in most cases, eliminated. Elevation of the legs opposes the anatomic and physiologic difficulty with the venous return. The legs and indeed the body in general can be exercised, preventing relaxation and atrophy. Increased intra-abdominal tension can be prevented by perfect closure of wounds, loose dressings and the skilful anticipation of intestinal distention. The trouble with all such measures is that in nineteen cases out of twenty they are not required—one must go gunning for the twentieth case! One should never, however, leave a patient, weakened by operation or disease, sitting up in bed for more than a few hours at a time. A permanent sitting or even reclining position, the legs being relaxed, is an invitation to thrombosis of the quiet type which so often causes especially nervous should be kept supine or even head downward until he is ready to begin getting out of bed. Indeed, unless the patient has a very vulnerable cardio-respiratory system, an elderly man subjected to prostatectomy had better remain, during the postoperative period, head down and feet up for a good part of each twenty-four hours.

The prevention of increased intra-abdominal tension has been dealt with by Bancroft and his associates. They insist that abdominal wounds be so carefully closed that tight strapping and binders are not needed and they regard the prompt

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restoration of intestinal tone by the early use of semi-solid or solid food as essential. Probably the surgeon's handling of the abdominal viscera at the operating table is equally important. An adequate fluid balance, as Collier and his co-workers have proved, merely requires an intelligent calculation. In these days, glucose (5 per cent) and physiologic saline solution are given, intravenously for the most part, according to the particular indications.

Measures directed against thrombosis should start at the earliest possible moment, not several days after the exciting factor has appeared. This has been realized by Best and his associates in Toronto in giving purified heparin after major operations. By establishing, within an hour or two of operation, a continuous intravenous injection at an appropriate dosage, they raise the coagulation time to fifteen minutes, maintaining it at this point for several days. Thus they have decidedly lowered, in a long series of cases, the incidence of thrombosis and embolism. The presence of heparin not only delays coagulation but prevents adhesion of the thrombocyte; that is, it completely abolishes thrombosis. Unfortunately, the treatment is expensive, and is certainly not available for general use. One may properly depend upon Bancroft's clotting index as a measure of the threat of thrombosis, taking special precautions or using an anticoagulant drug for the case in which thrombosis seems imminent. For an account of the test, Bancroft's writing should be consulted.

An index of over 1. points to a tendency to thrombosis and the need of preparing the patient by the use of a high protein, low fat and carbohydrate diet. Whether or not this diet is given, sodium thiosulfate in 10 per cent solution is administered intravenously for three consecutive days in a daily dose of 10 c.c.

The treatment of established thrombosis must always hasten the return of blood from the legs and pelvis. A solid thrombus, it must be supposed, occupies the upper femoral and more or less of the iliac vein.

But now the question arises: is a loose, detachable, propagating clot present at the proximal end of the thrombus? In the usual outspoken phlegmasia alba dolens it is very rarely present; in the occasional quiet, barely noticeable thrombophlebitis it may well be. However, the only clear proof of its existence is the occurrence of a pulmonary infarction due to a non-fatal embolus. Therefore, unless one believes that the common iliac vein or vena cava should be divided rather often on suspicion, the possible presence of the propagating process must be ignored and all efforts directed against its formation. It isn't the patient's turning over in bed which is responsible for the fatal embolism, but the presence of the detachable embolus; and the best practical defense against the formation of the embolus is elevation of the lower limbs.

Elevation of the legs has two objects: the hurrying of a collateral stream past the proximal end of the thrombus, to prevent the growth of the fragile clot which a slow stream encourages, and the relief of edema. There is no reason why the leg should not be elevated and no reason against its being moved, the proximal end of the thrombus being within the pelvis and little influenced by such factors. Indeed, why worry about casual exercise when the patient must practice daily the athletic feat of using the bed pan? Therefore the foot of the bed should be raised 4 to 6 inches and the swollen leg elevated still more upon an inclined plane or in a sling, as de Takats has suggested. A couple of pillows may be placed under the shoulders and head, but the body should not be bent by raising the upper half of the adjustable bed. Under these conditions, the leg will have freedom of motion and should not be covered with ice bags. Beyond the fact that heat usually brings more comfort—if the thigh is painful—the ice bag delays the flow of blood rather than hastens it and occasionally inflicts a frostbite. The old custom was to sit the patient up in bed, the flaccid legs outstretched, apply ice and wait for swelling and fever to subside. The ideal system is to raise the limb above the body,



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*Thrombophlebitis in the Prostatic and Uterine Veins.* Thromboses found at autopsy in these vessels have indicated them

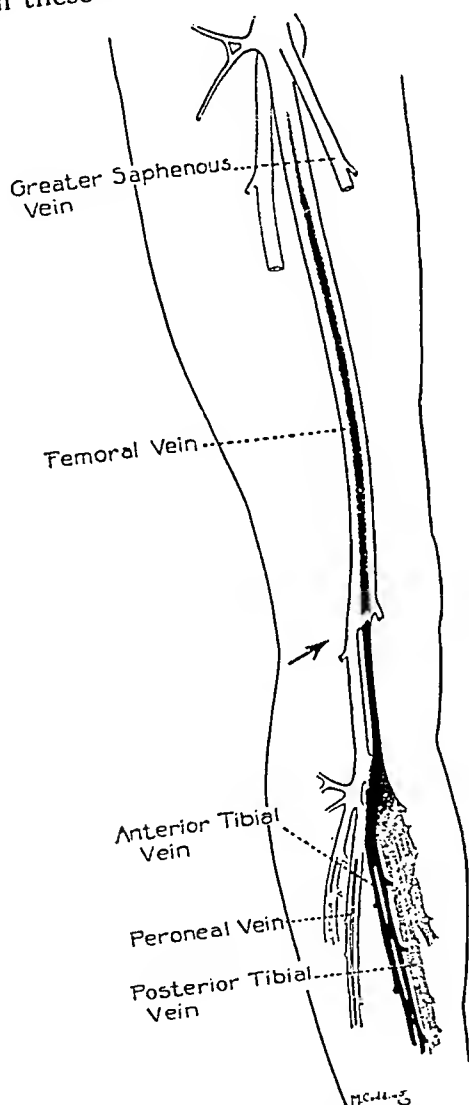


FIG. 2. Thrombophlebitis in the deep veins of the calf (from an autopsy description). A propagating thrombus is shown as if it had just broken off—arrow indicates point of rupture—a typical, long, fatal embolus, certain to cause death by plugging the pulmonary vessels.

to be a source of fatal pulmonary embolism, especially when no other source is discovered. Probably thrombosis is able to progress from the plexus of veins draining the prostate or the uterus through the hypogastric vein into the common iliac, obstructing the return from the leg and

causing phlegmasia alba dolens. Indeed such must be an occasional cause of that disease. But may a long, non-obstructing, loose clot spring from a prostatic or uterine vein and may it break off leaving only the parent thrombus deep in the pelvis? That seems to be unknown. There is certainly no way of identifying such a process during life. One can only hope that the routine treatment intended to forestall a femoroiliac thrombophlebitis will prevent its occurrence.

*Thrombosis in the Deep Veins of the Lower Leg: Deep Peripheral Thrombophlebitis.* This treacherous disease has been little described. It occurs during active life and not as a result of the events which lead to a femoroiliac process. Indeed its cause is usually trivial, a minor injury below the knee, a strain, a fracture of one of the bones of the foot, something which usually produces no such effect. It has been known to complicate a respiratory infection or an old rheumatic condition.

The veins involved are one group or several groups in and among the great flat muscles of the calf, some part of the posterior tibial, peroneal or anterior tibial systems; and since there are many more of these veins than are needed except when the muscles are at full use, hardly a sign of venous stasis, under a condition of rest, need appear. The first symptom of disease is usually a little lameness on forced dorsiflexion of the foot, or in putting the weight on the toes, as in walking up stairs. The ankle, perhaps the whole lower leg, may be slightly swollen, the foot a little cyanotic. However, the local signs tend to seem unimportant, and if the patient goes to bed for a few days they entirely disappear. There is usually no tenderness even on deep pressure into the calf. However, no sooner has the individual, from whose leg three or four days in bed have entirely driven the initial soreness and swelling, begun to go about again than the early signs return. Let him rest and exercise, rest and exercise, as in a case subsequently to be described, and he runs a

fair chance of dying of pulmonary embolism. For it is under such conditions that the long propagating thrombus is most apt to form.

The diagnosis is made upon the clinical events described in the preceding paragraph and upon a sign which in my experience seems pathognomonic. This is a sense of discomfort experienced by the patient when the tendo Achillis is put upon the stretch by forced *passive* dorsiflexion of the foot. The discomfort is felt back of the upper calf and knee. This is usually associated with some limitation of the movement attempted. The difference between the two legs is usually very clear to the patient. Not only is this test useful in diagnosis but in following the progress of the disease, for with healing of the thrombosis and the reestablishment of a normal circulation, the sign disappears.

*Treatment* varies with the stage at which disease is first seen. If the patient has but just complained of lameness and now for the first time exhibits a slightly swollen, bluish foot and soreness on forced dorsiflexion, conservative treatment should be tried. The lower end of the bed is raised on blocks 4 to 6 inches above the upper, and the leg is placed on a soft pillow. A large cradle is used to keep the bedclothes off the feet. No restriction is placed on moving the leg, but on the other hand no special attempt is made to exercise it. A couple of pillows may be placed under the head and shoulders. If the patient is able easily to manage the bed pan for defecation he should do so. If not, he had better get up once a day (applying a semi-elastic bandage from toes to knee) and use the bedroom cabinet.

Elevation in bed is maintained for at least ten days or until edema and all signs of soreness on forced dorsiflexion of the foot have disappeared. The next four or five days are spent in gently exercising all the muscles of the leg in bed. For it is held that such exercise should precede getting up and that a propagating thrombus need not at this time be feared. Then the patient

begins to get about, wearing, when he first walks, a semi-elastic bandage from toes to knee. He feels his way along, walking a little and again elevating the leg, gradually increasing the periods of use and shortening those of rest. If no swelling or blueness of the foot is noticed, an active life is resumed, the whole period of treatment having lasted three to five weeks.

If, on getting about, swelling and cyanosis recur or if the patient is first seen when he (or she) has already, during several weeks, undergone successive periods of elevation, apparent recovery and a return of the original signs, the femoral vein is at once divided distal to the profunda. For it is believed that thrombosis is still then active—is even perhaps extending—and that a propagating thrombus may well be growing up the femoral vein. There is all the more reason for femoral division in that experience has shown such treatment to cure the disease with remarkable rapidity. Of course it removes the danger of pulmonary embolism, and though one might suppose that division, even below the profunda femoris, would cause, for a moment at least, cyanosis of the foot, no such thing happens. The foot, which is usually a little cold, becomes warmer and even perhaps pinker than the other. In other words, a peripheral vasodilatation occurs.

Division of the femoral is performed under local infiltration with procaine. A 10 to 12 cm. oblique incision parallel to the inguinal ligament and about 3 cm. below it is satisfactory. The great saphenous vein is first found and is preserved as the best guide to the femoral. With retraction upward and downward upon the parts superficial to the aponeurosis, this layer is divided peripherally from the saphenous opening, exposing the common femoral just proximal to its division. Perhaps 2 or 3 cm. of the superficial femoral are isolated, ligatures are applied, the proximal just distal to the profunda, and the vein is divided between them. This gives a good cuff both proximally and distally. If a segment is to



be excised, a longer exposure of the vein is needed. The wound is closed in layers with fine silk and requires only a local dressing.

Following femoral division or resection, the patient remains in bed, the foot of which is kept elevated 4 to 6 inches, for a week or for such a period as the surgeon feels is required for the healing of the wound. The thrombosis is no longer important. The lower leg is bandaged when walking is begun, but a normal life can soon be resumed. In my own experience, cyanosis is not afterwards noticeable, but a little edema on hard usage of the leg may be present for some months.

Three typical cases of this disease are briefly described below. The first resulted in death from pulmonary embolism, the second was cured by conservative treatment and in the third, the superficial femoral vein was divided.

N. C., an active man, 50 years of age, suffered a fracture of the fifth metatarsal bone in a minor accident. A plaster cast was applied for a week. For the next four months swelling of the ankle and moderate discomfort in the calf occurred repeatedly upon use of the leg and rapidly disappeared upon rest in bed. At the end of this period he died of pulmonary embolism. The 12 to 15 inch embolus was found to have been detached from the point at which a large thrombosed vein joined the popliteal, as shown in Figure 2. The femoral vein was never occluded. Here was a fatal, easily detached, propagating clot, encouraged to form by partial occlusion of, and retardation of the current in, the venous tree and never subjected to continuous elevation.

By contrast, prompt elevation following the establishment of thrombosis in these same vessels seems to have a favorable effect and is likely to cause the thrombosing process to recede and heal. The following is a case in point:

J. M. H., a vigorous athletic man, 27 years of age, was first seen when, some four days after jumping a brook, one leg had become lame, the ankle and calf considerably swollen but without

any ecchymosis. He displayed the sign, already described, which I believe to be characteristic of this disease, that is, a painful soreness noticed high up in the back of the calf upon forced dorsiflexion of the foot, by which the tendo Achillis is put on the stretch. The foot of his bed was elevated 6 inches; the leg placed on a soft pillow but not immobilized. In a week, the swelling had disappeared. In ten days, all soreness on passive dorsiflexion of the foot had gone. Free exercise of the leg in bed was then begun, and in three weeks the patient was going about as usual. There has been no recurrence.

R. C., an active man, 48 years of age, severely wrenched his left leg playing tennis and may have torn a muscle in his upper calf, because he afterwards noticed considerable ecchymosis. He kept about for three days, his lower leg a little swollen and painful but finally went to bed where he remained for a week. Considering himself well at the end of this time, he went about again but once more the foot became swollen and cyanotic, driving him to bed for the second time. Again he got up, again his foot became swollen and blue. Six days later I saw him. His left leg appeared normal but turned a little blue on being left dependent out of bed. There was discomfort behind the knee on forced dorsiflexion of the foot. A diagnosis of thrombosis in some of the deep veins of the great calf muscles was made.

At operation, about six weeks after the original injury, the superficial femoral vein was divided just distal to the profunda. The excised segment was not remarkable. The immediate effect of the operation was to make the foot warm and of normal color.

The patient remained in bed for a week. Then he went about, using a bandage for the second week. From this time on the leg gave less and less trouble and in six weeks following the operation the patient had ceased to notice it.

*Thrombophlebitis in Varicose Veins.* The fibrosed, unhealthy state of the varicose vein's wall, associated with a feeble or reversed current, is explanation enough of the common thrombosis of varix. One may presuppose infection in tissues of lowered resistance, or believe that the lining of a dilated, pocketed varicose vein actually cracks under heavy back pressure, since

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pressures of arterial height have been recorded on coughing or straining. The wonder is, not that thrombosis occurs sometimes, but that it does not occur always. It usually appears near the knee, more often below than above and in a prominent dilated vessel or pocket. From its point of origin it progresses erratically upward and for an uncertain distance, but once half way up the thigh it is apt to reach the saphenous opening. Beyond this it rarely goes; that is, it rarely grows into the femoral either as a solid occluding thrombus or as a propagating clot threatening embolism.

The failure of thrombosis in a varicose vein to invade the femoral is a good example of the ending and healing of thrombosis where it encounters a strong blood stream. I know of only three instances of pulmonary infarction caused by thrombophlebitis in varix. Of these, two were successfully treated by high division of great saphenous; the other was diagnosed only from the history and is in fact unproved. Apparently the best reason for the solid attachment of a thrombus in the great saphenous vein is again the unhealthy state of the vein's wall. This is in accord with the general principle already discussed, namely that the more outspoken the thrombophlebitis the less the danger of embolism. The dependent position of the leg—most of the time—has little to do with the confinement of the process to the varicose vein. Else the subject of varicose thrombophlebitis had better never lie down.

The thrombophlebitis of varix is occasionally acute and associated with a redness, tender skin, local edema and some induration. Occasionally a great plaque of inflamed skin and thrombosed veins occupies the inner or posterior face of the calf. However, actual softening and supuration is almost unknown. The process tends rather to become chronic, the thrombus remaining fixed in the vessel with little change over a period of several weeks. In the end, a combination of soften-

ing and organization occurs, by which the lumen of the vessel is restored and it regains something very much like its previous state. But once having been thrombosed, a varicose vein is always liable to a recurrence, which is a sufficient reason for dealing radically with the process.

*Palliative Treatment.* There are two ways of making the thrombosis of varix last a long time: the first is to go about without an elastic bandage, the second is to go to bed, sitting up with the legs outstretched in a horizontal position. Both methods keep the venous stream slow and encourage continued thrombosis. By contrast, the process is made to disappear by applying an elastic bandage and leading an active life, or, rather more effectively, by elevating the feet above the head and so remaining in bed. The first of these last two methods is especially useful when thrombosis is confined to the lower leg so that an elastoplast bandage can be firmly applied from the toes to the knee, that is, up to a point well above the level of the process. Ten days of such treatment—elastic pressure hastens the venous stream—often causes the thrombus to disappear, but of course does nothing to prevent a recurrence. Elevation of the leg in bed probably acts more quickly and has the advantage that it is equally successful when thrombophlebitis is present in the thigh. Indeed, when the process has reached the saphenous opening, it is the only satisfactory treatment.

Local applications are not essential. If any are used, heat is preferable to cold. It encourages hyperemia, brings comfort and presumably discourages further thrombosis. Whereas the traditional ice-bag retards the circulation, devitalizes the tissues and encourages an extension of the thrombus. The only good which can be said of the ice-bag is that it is often comforting, quite as much so as the hot water bottle.

*Curative Treatment.* To check thrombosis, shorten the patient's disability and prevent recurrence of the disease no other procedure can compare with resection of



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the great saphenous vein at its entrance into the femoral. The only contraindication to the operation is the presence of a thrombus in the upper part of the vein. However, this contraindication is not absolute and in many cases it is difficult to decide before operating whether or not thrombosis has actually mounted to the saphenous opening. Should the presence of a thickened vein and local tenderness give warning that such is actually the case, the patient had better be subjected to the routine elevation of the foot of the bed. Within ten to fourteen days, the local thickening and tenderness will usually have disappeared, showing that the thrombus has been organized or liquefied. As one follows a superficial thrombosis by palpation, one is aware that the vein is becoming continually softer, so that it is less and less easily palpated. From being a solid cord, the size of a lead pencil, it will often, in a space of ten days, more or less, take on the character of a barely palpable vessel. Its wall will have become thickened, but not to such a degree as to suggest that the whole thrombus has been organized. Apparently the most clot-like portion is liquefied and carried away.

Once the upper saphena magna is again clear, it may well be resected. Opinion will naturally be divided as to when the operation should be performed. The likelihood of recurrence is such that a high division had better be made sometime. Why not, therefore, resect the vein at once and avoid a subsequent hospitalization?

Should the thrombus end proximally below the saphenous opening, the operation of dividing the great saphenous vein is performed in exactly the same way as for uncomplicated varix. One should have in mind, however, that almost every superficial thrombophlebitis is associated with some involvement of the perivenous lymphatics and some degree of lymphadenitis at the saphenous opening. Any suggestion of enlarged inflamed nodes is therefore a signal for especial care lest the glands be disturbed and spill infection into the wound. However, such an infection never

seems actually to suppurate. Following high resection of the great saphenous, the thrombosis clears up very rapidly. The varicose veins as well are usually cured. Should inflamed thrombosed veins, skin and subcutaneous tissue remain after the greater part of the thrombosis has resolved, it may require a clean removal, the edges of the incision being drawn together to cover the elliptical gap.

*Thrombophlebitis in Non-Varicose Superficial Veins.* The form known as *phlebitis migrans* is often a complication of thrombosis, *angiitis obliterans*. There it takes on its most typical appearance. However, a disease, seemingly in other respects identical, does occur in those who are not sufferers from Buerger's disease. In some of these there is a tendency to recurrence throughout life. Without any obvious cause, a stretch of vein, an inch or two in length, almost always upon the surface of the lower leg, becomes solid, thickened and slightly tender. In this state it remains for a week or two, and then, as it softens and apparently returns to something very much like its normal condition, another area of thrombophlebitis, considerably proximal to the first, appears. The first may occupy the region of the ankle, the second, the upper calf and a third, perhaps, the lower thigh. There is little tendency to embolism and continued use of an elastoplast bandage is about as successful as any other form of treatment. Whether the disease would promptly disappear (on any one occasion) if the leg were subjected to continuous elevation I do not know. It is usually treated by only partial rest and elevation and has exhausted everyone's patience before it ceases to break out.

The superficial thrombophlebitis which does not take the form of *phlebitis migrans* is actually more freakish and unaccountable than any other. It occurs most often perhaps in locally dilated veins which, however, are not a part of a varicose saphenous system. Local chafing, as in horseback riding, has been known to bring it on. Exposure to unusual cold, a severe

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bout of coughing, a trivial injury of any sort may occasion thrombosis. It seems to have the faculty of holding on, so to speak, for considerable periods, and if not promptly cured may at any time quietly march out of a small radical into the main stem of the great saphenous and from somewhere in the course of that vessel give off an embolus. Altogether it is difficult to know whether or not to fear it. For in most cases such a thrombosis must heal with little to show for its presence. It must also be admitted that among adipose women, in whose fat a local thrombosis is not easy to identify, the diagnosis between it and a local lymphangitis or mild cellulitis must often remain doubtful.

*Treatment.* Following the general rule, the superficial form, if only suspected of being present, should be treated by elevation—of the legs above the head—for a period of perhaps ten days. This period is set to offer a safe margin for the cure of a thrombophlebitis not easily palpated and therefore difficult to follow clinically. As a matter of fact, I have seen it disappear completely from a vein near the ankle in less than a week. But if, as so often happens in this and other sorts, the thrombosis has already persisted for several weeks when first seen, it should receive more radical treatment. That is to say, the parent vein, usually the great saphenous, should be divided at the saphenous opening, after which the process is soon healed.

*The Treatment of Minor Embolism*

The treatment of such thrombophlebitis as has already caused minor embolism, that is, pulmonary infarction, offers a fascinating and difficult problem. In the case of femoro-iliac thrombophlebitis, the difficulty of determining whether a propagating clot is present and if so where it is, has already been discussed. Nevertheless there are undoubtedly occasions when the pelvis must be exposed and the attempt made, notably when septic thrombi of small

size have been detached over a considerable period.

In the case of a deep thrombophlebitis among the muscles of the calf, the femoral vein distal to the profunda should be divided, a relatively simple procedure performed under local infiltration with procaine.

In the rare event of minor embolism from the varicose or non-varicose great saphenous vein, the matter is very simple, provided thrombosis does not occupy the vein at its junction with the femoral. If the saphenous can be divided above the loose clot, resection at the saphenous opening should be performed. If a serious but not fatal embolism has already occurred and there is evidence that from the fully thrombosed saphenous vein a loose clot is being propagated into the femoral, it is tempting to suppose that one can expose the common femoral above the entrance of the saphenous and while compressing the vein below the saphenous, open the femoral above. Then it should be possible to remove the clot by suction and divide the femoral, a decidedly nerve-racking procedure. If no propagating clot is found, division of the femoral vein would be less hazardous.

My own adventures have been with one instance of embolism from a thrombosis of the varicose saphenous in the mid-thigh during pregnancy, in which division at the saphenous opening was simple and curative, and with several instances of embolism supposedly from the great saphenous but in which the signs of thrombosis were no longer present. In these latter cases, exploration at the groin showed that a recent thrombophlebitis had actually occupied the great saphenous but was nearly resolved and organized; that is, the immediate danger of further embolism was over. It was then obvious that resection of the great saphenous at the femoral junction was indicated to prevent future attacks of a similar sort.

In general, my experience has led me to believe that whenever thrombosis in a

## Homans—Thrombophlebitis

great vein, the femoral or any other, is encountered in an attempt to divide the vein proximal to the thrombosis, it is best to sever the vein through the clot. For in every case in which I have done so, a good deal of blood has been found seeping through and about the thrombus, encouraging the continued growth of its soft, friable, proximal end. I was recently faced with an instance of this sort in a patient whose heart was none too sound, and who had already suffered many pulmonary infarctions. In trying to cut off further embolism from its supposed source in the popliteal vein, I unexpectedly found the femoral thrombosed. The process could be seen to extend well into the external iliac. Finding that blood poured freely from the opened femoral vein, I divided the vessel, hoping to cut off the remaining current. Following the operation, the foot of the patient's bed was elevated 6 inches and he was encouraged to exercise his legs. No further infarctions having occurred in the following ten days, he was allowed gradually to get about and has since remained well. I cannot help attributing some part at least of the good result in this case to full division of the thrombosed vein and the subsequent encouragement of a brisk collateral circulation. Doubtless venography will in time throw further light upon this difficult subject.

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# THE MANAGEMENT OF ARTERIOVENOUS ANEURYSMS IN THE EXTREMITIES\*

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ARTERIOVENOUS aneurysms in the extremities present so many interesting problems for clinical and laboratory investigation that much of the recent literature on this subject has been devoted almost exclusively to the pathologico-physiologic phenomena associated with abnormal communications between arteries and veins. Consequently, it has been difficult for the practicing physician and surgeon to gather from these publications the essential and practical information necessary for the efficient management of these serious surgical problems. It is our hope that, by deleting the controversial and highly scientific theories concerning these surgical lesions, we can present, in a concise form, that information which should be of immediate and practical value to those who must assume the responsibility of caring for patients with arteriovenous aneurysms in the extremities.

In this discussion we shall deal only with those arteriovenous aneurysms which result from a single communication between a large artery and a neighboring large vein. Such abnormal vascular communications are usually the result of penetrating wounds, such as gunshot or stab wounds, although occasionally a single arteriovenous communication of this type is either spontaneous or congenital in origin. From a strictly anatomic standpoint, the ordinary cirroid aneurysms and, perhaps, many of the simple angiomas are the result of multiple abnormal communications between small arteries and veins,<sup>1</sup> but this great group of congenital vascular lesions rarely presents the serious clinical problems or leads to the mistakes of management which so frequently occur when the local

vascular derangement is the result of a true arteriovenous aneurysm.

The *differential diagnosis* between a pulsating hematoma or false aneurysm which results from a puncture of the coats of an artery, and an acute arteriovenous aneurysm is sometimes exceedingly difficult, during the first few days after the arterial injury. The pressure from a large hematoma at the site of injury of large blood vessels may obscure all of the classical signs and symptoms of an abnormal arteriovenous communication. It may be several days before the appearance of the characteristic thrill and bruit.

In the case of an unimpeded arteriovenous fistula, the characteristic to and from murmur with a marked intensification initiated by systole of the heart, cannot fail to be elicited by simple auscultation over the injured area. Palpation over the same area always gives the unmistakable continuous thrill produced by the rapid passage of arterial blood through the abnormal communication into the vein. The marked alteration of the local venous pressure usually produces enlargement and tortuosity of the superficial veins of the extremity. These changes in the veins first take place in the region of the injury to the vessels, but later may involve other veins throughout the affected extremity. (Fig. 1.) The intravascular pressure changes in these superficial varicosities are usually so pronounced that the veins actually pulsate with each inrush of blood from the injured artery into the injured vein.

The *pathologic-physiology* of such abnormal communication between arteries and veins must be thoroughly understood if the most effective treatment is to be out-

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lined for any given patient. The effects of arteriovenous aneurysms are usually limited to the site of trauma during the

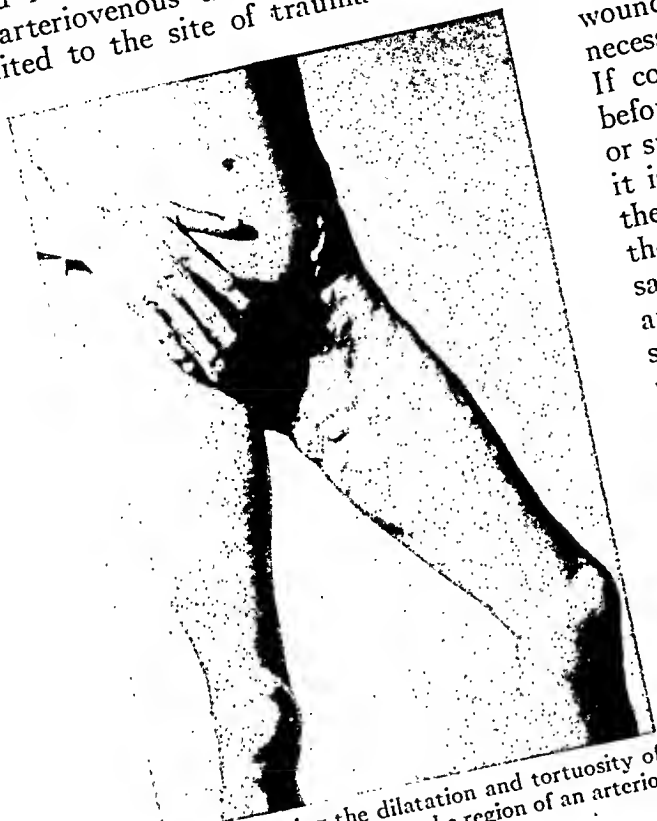


FIG. 1. Showing the dilatation and tortuosity of the superficial veins in the region of an arteriovenous aneurysm.

first few hours or days following the injury but in certain rare instances the added work upon the heart causes such serious cardiac embarrassment that immediate surgical intervention is necessary to save the patient's life. Mason,<sup>2</sup> Stone, and others have described acute cardiac dilatation due to the sudden shunting of large quantities of arterial blood into great veins and thence into the right side of the heart. This immediate complication is rare, but it is of such great importance that the attending physician or surgeon must constantly keep it in mind. Clinically the occurrence of tachycardia, dyspnea, peripheral edema and marked enlargement of the heart should lead one to suspect this complication.

The loss of considerable blood to the exterior from the penetrating wound is frequently alarming to the patient, but

rarely requires any special operation to control the hemorrhage. The elevation of the extremity with the application of the finger or a piece of sterile gauze over the wound in the skin is frequently all that is necessary to control the external bleeding. If considerable loss of blood takes place before the patient is seen by the physician or surgeon or before first aid can be given, it is then frequently necessary to restore the blood volume to an adequate level by the intravenous administration of normal saline solution or 5 per cent glucose solution and the transfusion of whole blood from a suitable donor before any further treatment is instituted.

Bleeding into the tissues of the extremity should be considered a more serious complication. The infiltration of the muscles with blood may continue until the pressure within the extremity becomes so great that the flow of blood through the collateral arteries is partially or completely cut off and serious ischemia of the distal portions of the extremity results. Such ischemia may be so complete that early gangrene of the distal part of the extremity takes place. Under such circumstances it may also be necessary to resort to operative treatment of the area to reduce this compression of the essential collateral arteries.

The development of signs of inflammation in the hematoma or in the damaged tissue about the arteriovenous aneurysm must be considered as a serious complication. Bacteria grow rapidly in this ideal culture medium and extensive suppuration usually leads to massive secondary hemorrhage through the external wound. If, therefore, definite signs of infection are present in and about the injured area, there is more risk to the patient's life in delaying active treatment with the hope that the infection will subside, than there is in immediately carrying out the necessary surgical treatment.

As the abnormal communication between the artery and vein becomes more permanently established, other changes in the dynamics of the circulation begin to

take place. These so-called *late effects* must constantly be borne in mind by the attending physician lest the optimum time for the performance of the curative surgical procedure will pass unrecognized and the myocardial damage will become so great that it enormously increases the risk of surgical intervention.

The pressure of the blood within the peripheral veins distal to the arteriovenous fistula is usually greatly elevated due to the increase in the resistance to the return flow of venous blood caused by the shunting of arterial blood into one of the large veins of an extremity. Such a rise in the peripheral venous pressure also occurs when a large hematoma or even a large arterial aneurysm presses upon one of the major veins of an extremity; consequently, a mere elevation of the peripheral venous pressure does not necessarily indicate the presence of an arteriovenous aneurysm. We feel, however, that a rise in the general venous pressure, as for example the elevation of the venous pressure in the arm when an abnormal arteriovenous communication of long standing is situated in the leg, should be considered of definite significance since it usually means that the added work which the arteriovenous aneurysm has thrown upon the heart has resulted in cardiac decompensation. We believe that there is usually no significant increase in the general venous pressure until there begins to be definite embarrassment of the cardiac function.

The changes in the systolic blood pressure are usually less marked but may be of distinct value in estimating the amount of added work which has been thrown upon the heart as the result of the arteriovenous communication. The ordinary blood pressure readings in the arm under such conditions are apparently within the normal range when the arteriovenous communication is located in the leg or in the opposite arm, but if the blood pressure is taken while the arteriovenous communication is temporarily occluded by external pressure, there is frequently a striking and rapid rise

in the systemic blood pressure. We regard this as an important clinical observation and the rate and degree of the rise of the blood pressure seems to bear direct relation to the extra work which has been placed upon the heart as the result of the arteriovenous communication.

The efficiency of the arterial circulation distal to the fistula may be greatly reduced. This subacute ischemia which occurs as a late complication to an abnormal arteriovenous communication rarely leads to frank gangrene of any of the distal portions of the extremity. It is not uncommon, however, to find that the interference with the nutrition of the muscles is so great that classical intermittent claudication develops after relatively slight exertion.

The associated dilatation of the superficial veins together with subacute or chronic ischemia of the extremity may also lead to the formation of chronic ulcers of the lower leg or ankle. These chronic ulcers are usually very resistant to treatment and due to the fact that they are surrounded by dilated blood vessels, it is not uncommon for profuse bleeding to take place after slight traumatization. The subacute ischemia of the distal portion of an affected extremity usually causes the skin of the foot to be paler and colder than the normal foot. Frequently, it is impossible to palpate a pulse in the pedal arteries when the abnormal arteriovenous communication is between the femoral vessels of that extremity.

However, the presence of an arteriovenous aneurysm is a powerful stimulus to the development of a collateral arterial circulation in an affected extremity. It has been frequently demonstrated that during a period of four to six months after the establishment of an abnormal arteriovenous communication, there develops around this fistula, a collateral arterial circulation which is much greater than that which develops after simple ligation of the artery. When this collateral arterial circulation is once developed it is possible for the surgeon to carry out almost any opera-



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tion necessary to close the communication between the artery and the vein even to the point of completely excising the portions of both the artery and vein which contain the fistula.

When an arteriovenous aneurysm occurs in the extremity of a growing individual, there is occasionally an actual lengthening of the extremity due to the increased vascularity about the growth center of the long bones. This same type of stimulation of local growth of bone may be associated with other diseases such as osteomyelitis and is, therefore, not pathognomonic of arteriovenous aneurysm.

The most important effects of a long standing arteriovenous aneurysm in an extremity are those which result from the added work upon the heart. The position and the size of the fistula between the artery and the vein determine to a great degree the amount of arterial blood which is thrown back upon the right side of the heart. During the early stages, the heart may compensate remarkably for this added strain but when the strain continues to act over a long period of time, there is definite enlargement of the heart due principally to hypertrophy and dilatation of the right ventricle. Such patients usually give a story of increasing dyspnea which has slowly come on over a period of weeks or months and an inability to take part in any competitive games due to easy fatigability. In the later stages, gross irregularity of the cardiac action may be observed by the patient or his physician.

In patients in whom the abnormal arteriovenous communication has been present for many weeks or months, it is frequently possible to get some advance notion concerning the added burden which has been thrown upon the heart by observing the degree of slowing of the heart action when the communication between the artery and the vein is temporarily occluded by digital pressure. This phenomenon, which is known as Branham's bradycardiac sign, is considered important evidence that the heart is being subjected to an abnormal

degree of strain as the result of an arteriovenous aneurysm.

The *pathologic changes* which take place in the vessels about the arteriovenous aneurysm are of great importance to the surgeon. The portion of the major artery just proximal to the arteriovenous fistula frequently becomes greatly enlarged and sometimes quite tortuous. The wall of this artery becomes very thin and takes on the anatomic characteristics of the vein. This structural change has been described by Holman<sup>3</sup> as "venification" of the artery. At the same time that the artery undergoes these changes, the major vein or veins which take part in the arteriovenous aneurysm become enlarged, but their walls become considerably thickened. This structural change Holman describes as "arterialization" of the vein. These changes in the vessels are undoubtedly the result of the great alterations in the local pressure within these blood vessels due to shunting of blood from the major artery directly into the major vein. In long standing arteriovenous aneurysms of the extremities, it is rare to find serious damage to the heart without marked dilatation of the artery proximal to the fistula.

## SURGICAL TREATMENT

During the evolution of an arteriovenous aneurysm from the time of the original traumatization of an artery and a vein in an extremity to the late stages associated with serious cardiac damage, there may be many different indications for surgical intervention either as emergency or lifesaving procedures or as elective and curative surgical operations.

Massive hemorrhage into the tissues of an extremity or the formation of a large hematoma may occur as an early complication of such vascular injuries. The compression of collateral arterial pathways in such an extremity may be so complete that the nutrition of the tissues distal to the injured vessels is seriously impaired. Early surgical operation with the evacuation of

all clots of blood should be carried out to relieve as much tension as possible on the vital structures of that extremity. The use of a tourniquet on the proximal side of the injury to the great vessels is usually necessary and a large incision in the skin and superficial tissues is recommended to provide an adequate exposure of the injured vessels. After all clots of blood have been washed out of the wound by careful irrigation with warm saline solution, the glistening intima of the injured artery is usually detected without difficulty.

If the wound in the artery is small and the edges are not seriously damaged it may be possible to restore continuity by the use of interrupted sutures of fine silk placed near each other. All clots of blood in and about the injured artery must be removed before any attempt is made to reconstruct it. It is also important to reinforce the suture line in the injured artery with a small flap of vein. The injured major vein should be ligated above and below the point of rupture of its wall and no attempt should ever be made to restore its continuity.

After all the bleeding has been controlled, the skin and superficial tissues external to the fascia should be brought together loosely by widely spaced interrupted sutures. A sterile gauze sponge moistened with warm saline solution should be placed directly on the sutured wound and the entire area then covered with some waterproof material to retard the desiccation of the wound and the dressing. The capillary action of the saline solution within the meshes of the gauze sponge helps to draw the old blood and serum out of the wound through the space between the sutures.

In those cases in which the artery has been completely severed, it is usually unwise to attempt to restore its continuity by suturing together the injured ends of the vessel. When the injury to the artery is so extensive we believe that the proximal and distal ends should be isolated carefully and then ligated with heavy braided silk or narrow cotton tape. The choice

of the suture material and its size should be governed by the caliber and activity of the artery which is to be ligated.<sup>4</sup> If the surgeon is skilled in the use of the Tuffier tubes it may be possible to restore the blood-carrying function of an injured artery for a sufficient length of time to permit the spontaneous development of an adequate collateral arterial circulation in the affected extremity. After an artery has been repaired by sutures or after the continuity of the injured artery has been restored by the insertion of a Tuffier tube, it may be wise to prevent further intravascular clotting of blood from taking place by the administration of purified heparin according to the method suggested by Murray, Best and their associates<sup>5</sup> in Toronto.

Since we also have available an active means of stimulating the flow of blood through existing collateral arterial pathways by the rhythmic alternation of the environmental pressure about an extremity in the form of passive vascular exercises,<sup>6</sup> we have ceased to worry about severe degrees of ischemia which occasionally make their appearance after these extensive surgical operations upon the vascular system. If the need arises we can usually restore the arterial circulation to an adequate level by this physical means and thus prevent the occurrence of degenerative changes in the distal part of the affected extremity. When the small arterial and arteriolar network is structurally normal only a few days of intensive passive vascular exercise treatment are necessary to get the flow of blood started through the existing collateral arterial pathways. This method of overcoming acute ischemia of the tissues distal to the injured vessels of an extremity must be considered as a valuable adjuvant and should be kept ready for immediate use during the active phase of surgical treatment. It has given us the added courage necessary to perform very radical surgical procedures upon the peripheral vascular system when such operations are absolutely



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necessary for the cure of the arteriovenous aneurysms.

In those acute cases where a tourniquet

should be used to ligate the major vessels even in the presence of infection and we prefer to leave these ligatures completely

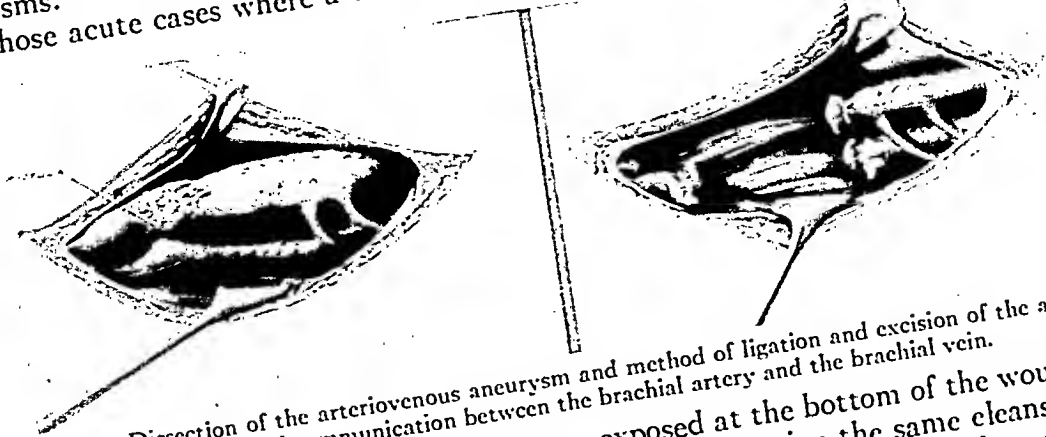


FIG. 2. Dissection of the arteriovenous aneurysm and method of ligation and excision of the abnormal communication between the brachial artery and the brachial vein.

cannot be applied proximally to the injury of the vessels, it is essential that some form of temporary occlusion of the major artery proximal to the aneurysm be performed before any attempt is made to cut into the aneurysm. Severe hemorrhage may result even when the incoming artery is temporarily occluded but the bleeding can usually be controlled by digital pressure after the clots of blood are rapidly removed from the wound. The ligation of the incoming artery should never be employed as a means of giving permanent relief. This proximal occlusion of the artery interferes greatly with the collateral arterial circulation and it is almost certain to lead to gangrene of some distal part of the extremity. The injured artery should be ligated immediately above and below the injured area in order to preserve as many of the collateral arteries as possible.

An emergency surgical operation is indicated if signs of infection make their appearance in the hematoma about the injured vessels. Experience has shown that delay in these cases may lead to massive secondary hemorrhage which is usually very difficult to control. The operation is performed exactly as we have already described for the treatment of massive hematoma about injured vessels, except that no attempt should be made to close the wound when infection is present. We believe that braided silk sutures or tape

exposed at the bottom of the wound where they will receive the same cleansing treatment which is given to the rest of the wound. The proper and judicious use of Dakin's solution after the first few days usually hastens the process of healing and does not contribute to the danger of secondary hemorrhage. With careful irrigation and dakinization of the wound, the healing processes usually take place without great delay and often without the need of removing the large silk ligatures which were used to occlude the major arteries at the bottom of the wound.

Occasionally an emergency operation must be performed upon the arteriovenous aneurysm because the patient is showing signs of acute cardiac decompensation. Such a patient will rarely tolerate any extensive operative procedure and the simplest operation which will remove the majority of the strain from the heart, should be done without delay. The simple ligation of the involved vein at a point 2 or 3 inches proximal to the arteriovenous fistula, usually gives a satisfactory degree of immediate relief. At some later time when the patient's heart is in better condition, the curative surgical operation can be carried out without undue technical difficulty.

In those patients in whom the arteriovenous aneurysm has been present for many months or years we believe that the

best chance for complete cure will result from excision of the involved artery and the involved vein together with the removal

In such instances the proximal and distal ligation of the artery is first performed and then transfixion occluding sutures of



FIG. 3. Quadruple ligation of the major vessels involved in an arteriovenous aneurysm. The method of occluding the fistula is shown in detail.

of the section where the two vessels communicate with each other. (Fig. 2.)

In other patients it may not be possible to free completely the site of the fistula, but under such circumstances the quadruple ligation of the involved vessels and all of the anastomosing branches will effect a complete cure of the aneurysm. However, after the ligation of all of these vessels, it is advisable, in case a branch has been overlooked, to occlude permanently the communication between the vessels by interrupted through-and-through sutures of braided silk. (Fig. 3.) Occasionally the fistula is so located that it is technically too difficult or dangerous to attempt to ligate all branches of the involved vessels.

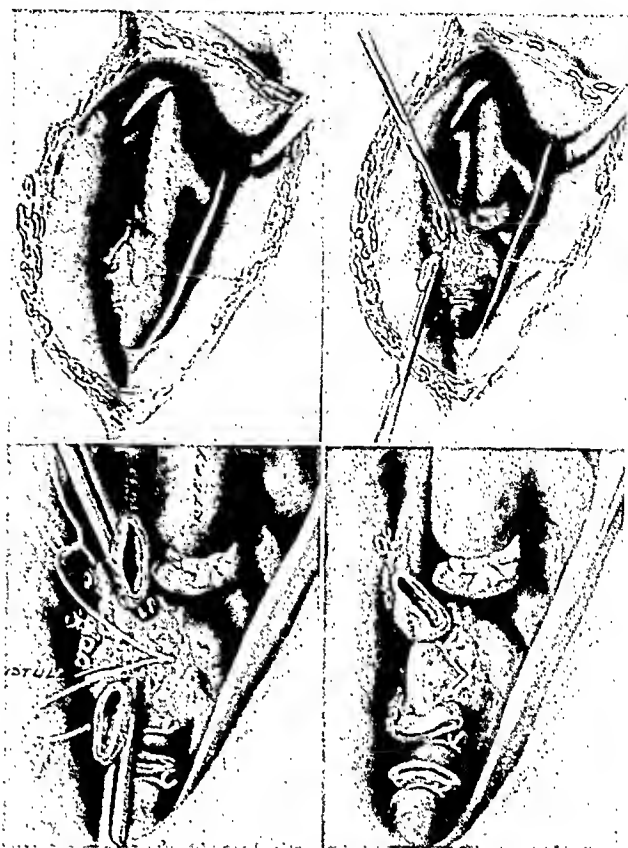


FIG. 4. Successive steps in the isolation of an arteriovenous aneurysm and the method of closing the abnormal communication between the artery and vein by means of the transfixion occluding sutures.

braided silk are placed in such a way as completely to occlude the fistula. (Fig. 4.) This procedure will also result in a complete cure of the arteriovenous aneurysm.

In young adults in whom the arteriovenous aneurysm has not existed long enough to produce the characteristic structural changes in the involved artery and vein it may be desirable to restore the continuity of the artery. This can be accomplished by exposing the fistula through an opening in the opposite side of the involved vein. This transvenous approach, as described by Rudolph Matas,<sup>7</sup> permits the surgeon to repair the opening in the artery and then reinforce the suture line with viable flaps from the vein. Attempts to reconstruct the vein may result in pulmonary embolism, and therefore the procedure should be discouraged.

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## REMARKS

The most essential fact concerning the elective operations for arteriovenous aneurysm is the absolute necessity of doing some surgical procedure which will completely prevent blood from passing through the fistula from the artery into the vein. In general, any operation which does not accomplish the occlusion of the abnormal communication will certainly not be a permanent cure of the aneurysm. We cannot condemn too strongly the procedure of simple ligation of the involved artery at any point proximal to the fistula. This operation is still commonly used in spite of the fact that it carries with it a high incidence of gangrene of the affected extremity. The procedure simply cuts off the main force of the arterial stream so that the small amount of arterial blood which finds its way around the collateral arterial pathways into the distal portion of the major artery immediately takes the path of least resistance by passing through the fistula and back to the heart, thus depriving the rest of the extremity of its proper nourishment.

We prefer to allow a period of from four to six months to elapse before performing any elective operations for the cure of arteriovenous aneurysms in the extremities since experience has shown that the collateral arterial circulation which develops spontaneously will greatly reduce the risks of complication resulting from serious arterial insufficiency in the distal parts of the affected extremity. This delay also permits the extravasated blood to become

completely absorbed and the tissues to return to a more or less healthy condition and appearance, thereby greatly reducing the probability of stirring up any old infection in the wound. When all of these dangers are removed the surgeon can freely choose from the numerous curative surgical operations that one which is best suited to his particular case and carry out the procedure without any fear that some serious complication will eradicate all his hopes for success. It is well to remember, however, that the surgical operations upon arteriovenous aneurysms are frequently very difficult and usually demand the greatest surgical skill, linked with sound surgical judgment. The execution of such operative procedures should not be attempted by any surgeon who has not had considerable experience with the suturing and ligation of large blood vessels.

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# ACUTE ARTERIAL OCCLUSION OF THE EXTREMITIES\*

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**A**CUTE occlusion of the peripheral arteries, although infrequent, occurs often enough to warrant keeping it in mind since suspecting it leads us to the examination which will furnish the diagnosis. This fact and the report of three additional cases constitute the justification for this review.

*Pathology.* Most authors agree that acute occlusion of a peripheral artery is the result of an embolus originating elsewhere. Occasionally<sup>1</sup> attempts are made to distinguish between embolism and acute thrombosis, but such differentiation is admittedly extremely inaccurate. Although thrombosis can occur, the process usually is so gradual as to allow the development of sufficient collateral circulation to prevent gangrene or even the acute symptoms which ordinarily are ascribed to sudden occlusion.

To lodge in the peripheral arteries, emboli must originate in the left heart, the arteries proximal to the site of lodgment, or the pulmonary veins. The great majority come from the left heart.<sup>3</sup> Most of the cases reported had suffered from myocardial disease and irregular rhythm and the occurrence of embolus not infrequently followed shortly after the reestablishment of normal rhythm, suggesting that a clot formed in the left auricle was expelled by the more vigorous and efficient contractions occurring with normal rhythm. Under this heading should be considered also paradoxical emboli which originate in the systemic veins and, due to a patent foramen ovale, cross the intraventricular septum, to be distributed in the systemic arteries instead of following the normal course from the right ventricle to the pulmonary arteries. This type is extremely

rare because of the low percentage of patent foramina.

The site of lodgment is almost entirely at some point of rapid diminution in the size of the artery and, because this rarely occurs except at a division of the vessel, one usually finds the block to be at one of the main divisions of the peripheral artery such as the transformation of the brachial into the radial and ulnar or the division of the common femoral into the profunda and superficialis, the division of the popliteal into the anterior and posterior tibials, et cetera. This knowledge is extremely helpful in localization of the block.

The consistency of the clot has considerable influence upon the effects. A firmly organized, fairly old, embolus tends to lodge firmly and to remain intact. This frequently allows collaterals distal to the block to maintain sufficient circulation to the periphery. A younger and softer embolus, on the other hand, may break up when it strikes a bifurcation and descend along the branches as several small emboli, thus blocking numerous small and terminal branches. This is much more likely to produce gangrene than the former type. In many cases, lodgment of an embolus is frequently followed by thrombosis extending from the embolus distally and, on occasion, even proximally. The thrombosis blocks more and more of the collaterals with increasing disturbance of the nutrition of the part.

With the occurrence of any embolic lodgment there is almost invariably more or less degree of spasm affecting the arteries supplied by the occluded vessel. This is often extreme and greatly diminishes what might otherwise be an adequate collateral circulation. It persists for a variable period,

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often twenty-four to forty-eight hours. This mechanism furnishes the rationale for the use of antispasmodics, such as papaverine, and accounts for the beneficial results frequently obtained when they are administered.

When embolism occurs in the peripheral arteries, the intima in contact with the embolus undergoes change, sometimes within two to three hours and occasionally not for twelve hours or more. If undisturbed, this process extends to such a degree that, even though the embolus be removed, thrombosis will immediately follow and again occlude the vessel. This accounts for the failure of surgical removal in late cases and even in some of the earlier ones.

One cannot overlook the importance of certain other considerations such as the elasticity of the vessels involved, the efficiency of the general circulation and interference with collaterals by previous pathology or anatomic variation.

**Symptomatology.** In the great majority of patients the disease is initiated by sudden, severe pain in the involved extremity. In a few there is gradually increasing pain or numbness of the extremity followed by pain. Occasionally there is no complaint of pain at any time. Practically all of the patients complain of extreme numbness of the extremity. Most of them have weakness or paralysis of muscles and a cold skin in the involved area. Upon examination the outstanding features are pallor, decreased skin temperature easily determined by the palpating hand, partial or complete anesthesia, absence of skin and tendon reflexes, and the extremely important absence of pulsation in the vessel distal to the occlusion. With the onset of gangrene pain is ameliorated.

**Localization.** Of necessity the evidence of ischemia will not extend proximally as far as the embolus since the branches arising proximal to the occlusion will supply the superficial tissues for a variable space. Thus a block of the femoral just below the profunda will cause little or no disturbance of sensation, color, warmth, or

function of the thigh, but will affect mainly the leg and foot from the knee downward and no pulsation can be felt in the popliteal. However, when the vessel under question is sufficiently superficial, as the brachial and axillary, one can determine by palpation the exact point where pulsation ceases. Also at this point one usually feels a firm and slight enlargement of the vessel.

Another helpful method suggested by Linton<sup>2</sup> is the application of a blood pressure cuff to the extremity at various levels. The indicator needle will show a definite oscillation above and little or none below the point of obstruction. Thus by shifting the cuff up and down the extremity one may obtain a fairly accurate localization. Unfortunately many lesions occur so near the trunk that this method cannot be applied. Arteriography has been utilized in a few instances to determine the location of the embolus when it could not otherwise be easily found.<sup>3</sup>

**Treatment.** From a limited experience and a study of the literature it appears that the best results are derived from (1) early diagnosis before ischemia produces irreparable harm; (2) abolition of spasm; (3) extraction of the clot or arteriectomy; (4) passive vascular exercise for increasing collateral circulation; and (5) protection of devitalized tissue from immoderate heat and from further deprivation of blood by elevation.

**Antispasmodics.** Since the degree of associated spasm is often surprisingly great, diminution or abolition of it frequently prevents gangrene and may allow restoration of normal function in spite of the persisting embolic occlusion. Although sympathectomy has been suggested it is a serious operation for such an ill patient and its good effects cannot be accurately forecast. General or spinal anesthesia add an additional load to an already ill patient and cannot be indefinitely prolonged.

Antispasmodics, such as papaverine and eupaverine, are equally effective, quicker in action, more simple and apparently non-toxic. They can be used to determine

quickly the degree of spasm and should be effective within a half hour. If, because of blockade of collaterals, extreme arteriosclerosis, etc., no immediate improvement is apparent, very little time is wasted and more radical methods can be adopted while they still may be helpful. Papaverine, gr.  $\frac{1}{4}$  to  $\frac{1}{2}$  intravenously should be given and, if the circulation returns to the part, should be repeated three or four times daily for four days or more. Denk<sup>4</sup> reports that in seventeen out of twenty-five extremities so treated recovery ensued without gangrene and that seven out of nine patients with pulmonary embolism survived. Using papaverine de Takats<sup>5</sup> saw rather dramatic improvement in five of six cases, including one instance of serious pulmonary embolism. In one the leg recovered under the administration of antispasmodics after passive vascular exercise had failed. Other individual case reports are suggestive.

**Embolectomy.** If circulation is not satisfactory within two hours after the use of antispasmodics the situation should be considered a surgical emergency and immediate operation done. If twelve hours or more have elapsed since onset, embolectomy will probably not be successful but occasional recovery has been reported after as much as forty-eight hours.<sup>4</sup> Accurate

TABLE I  
EMBOLECTOMY

Author	Number of Extremities	Extremity	Recovered without Gangrene	Indeterminate (Died too soon)
Linton <sup>2</sup> (44 cases)	12	Axillary..... 1 Iliac, femoral, and popliteal. 10 Aorta..... 1	1 3 0	3
Lund <sup>8</sup> (55 cases)	30	Arm..... 7 Leg..... 23	6 9	0 4
Pearse <sup>3</sup> (282 cases)	282	Arm..... 46 Leg..... 205 Aorta..... 31	20 58 7	
Key <sup>4</sup> (43 cases)	48	Arm..... 4 Leg..... 42 Aorta..... 2	4 14 (6 showed good local effect but died)	20 1 gangrene (good localization)

localization, the Carrell technique, local anesthesia, and gentle extraction of the clot without intimal damage often lead to the reestablishment of the flow through the artery.

TABLE II  
SYMPTOMATIC TREATMENT

Author	Number of Extremities	Extremity	Recovered	Indeterminate (Died too soon)
Linton <sup>2</sup> (44 cases)	18	Arm..... 5 Leg..... 13	4 1	
Lund <sup>8</sup> (55 cases)	30 (without operation; other treatment not specified)	Arm..... 7 Leg..... 23	5 4	2 3

TABLE III  
PASSIVE VASCULAR EXERCISE

Author	Number of Extremities	Extremity	Recovered without Gangrene	Indeterminate (Died too soon)
Linton. <sup>2</sup> Negative element alone: 2 out of 6 extremities recovered. Negative-Positive: 7 out of 9 extremities recovered.	15	Aorta..... 6 Iliac, femoral, and popliteal. 9	3 6	2 1
de Takats <sup>5</sup>	3	Leg..... 3	0	
Hermann and Reid <sup>6</sup>	10		10	

Table I gives an idea of the recoveries in some 500 cases. It is evident that the legs are much more likely than the arms to become gangrenous when major vessels are obstructed. In fact, a few observers suggest that it is unnecessary to operate upon axillary or brachial occlusion.

Reference to Table II, concerning symptomatic treatment only, shows a high percentage of recoveries without operation and apparently without antispasmodics or vascular exercise. However, it is logical that effective methods applied early should improve this percentage even in the arms which are so favored anatomically. The

## Burnett—Arterial Occlusion

major difficulty in comparative statistics here is the high mortality among these patients from the original pathology, such as heart disease, or from associated emboli to vital organs as the brain, kidney, etc., death often occurring before results of treatment to the extremities can be evaluated.

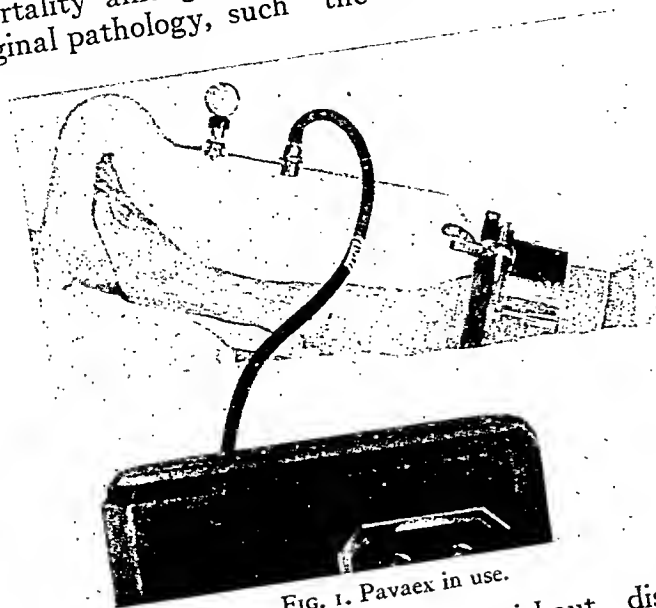


FIG. 1. Pavaex in use.

as heart disease, or from associated emboli to vital organs as the brain, kidney, etc., death often occurring before results of treatment to the extremities can be evaluated.

*Passive Vascular Exercise.* This has been reintroduced and modernized by Hermann and Reid<sup>6</sup> and Landis and Gibson.<sup>7</sup> It produces definite improvement in most cases of such inadequate circulation and frequently prevents gangrene. Table III summarizes some available reports. If immediate treatment by antispasmodics and/or embolectomy is not successful, or if the patient is seen too late for their use, the pavaex treatment of alternate negative and positive pressure is definitely indicated and extremely beneficial. Hermann and Reid advise slow oscillation of from 40 mm. of mercury positive to 80 mm. of negative pressure with four cycles per minute, five of each fifteen seconds of a cycle for the positive and ten seconds for the negative phase. An additional substratum of short oscillation occurring eighty to one-hundred times per minute throughout both phases is included in the apparatus designed by Hermann.<sup>6</sup> The treatments are from one-half to two hours and should be given

out without discomfort or untoward effects."

Arteriectomy has recently been advocated by Leriche.<sup>9</sup> Since ligation of a vessel at any given point is much less likely to produce gangrene than embolus to the same point, the thought is to excise the segment of the artery so damaged by the lodgment of an embolus that thrombosis follows its extraction. This author feels that an excision of the involved portion of the vessel with ligation of the adjacent remnants will substitute ligation with its lessened danger of gangrene for thrombosis with its associated spasm and likelihood of propagation of the clot. He reports one such case with recovery in six hours after arteriectomy.

One must not forget that considerable harm may ensue from elevation of the extremity affected by arterial occlusion, allowing rapid return of the blood through the unobstructed veins and further increasing the ischemia; that tissues deprived of blood supply are easily damaged by temperatures above 100 degrees and that delay in applying appropriate treatment greatly decreases the chance for recovery of the part.



## CASE REPORTS

CASE 1. Mrs. I. S., age 47 years, was admitted October 31, 1935 because of cardiac failure with auricular fibrillation, the result of rheumatic heart disease from which she had suffered for the previous fourteen years. She was dyspneic and her legs were immensely swollen. Weakness and severe precordial pain were also present. Examination revealed a marked degree of arteriosclerosis, an enlarged fibrillating heart with extensive evidence of myocardial failure. Laboratory studies revealed no diabetes, a negative Wassermann, and a normal blood count except for a leucocytosis to 17,000 with 80 per cent polymorphonuclears of which 28 were non-filamented.

Slightly over two weeks later, at approximately noon, she was suddenly seized with precordial pain and almost simultaneously with severe pain in the left arm and hand; a few minutes later severe pain also appeared in the right hand and arm. The hands were blanched, cool, and no pulsation could be found in the arteries of the vessels of either arm, on the right below the axilla and on the left below the mid-brachial areas. Morphine sulphate, gr.  $\frac{1}{3}$  and nitroglycerine and amyl nitrite relieved the substernal but not the brachial pain. However, she became comfortable in the next two hours and the color and warmth partially returned to the hands although no pulsations could be felt in the vessels. At 5 o'clock in the afternoon pain returned and both hands and forearms became cyanosed and cold.

She was seen at this time in consultation and, although some five and one-half hours had elapsed since onset, embolectomy was advised. This was done immediately, approximately six hours after the onset. Under local anesthesia the right axilla was opened over the point where the pulsation ceased and, with the Carrell technique, the artery was opened and a firm, slightly adherent, clot was removed. A good flow of blood was obtained proximally but only a slight flow distally. The intima was somewhat discolored and roughened. The artery was closed and compression released and for a few seconds pulsations could be palpated in the brachial though none reached the radial at the wrist. After about sixty seconds pulsations gradually ceased and although sutures were removed and another soft

clot extracted the same thrombotic result again occurred. The left brachial was exposed midway between the shoulder and elbow where pulsation ceased and a high division of the brachial into the radial and ulnar branches was discovered at this point. There was a hemorrhagic band about 2 cm. wide at the bifurcation, below which no pulsations were noted. The vertical incision was made and a rather firm clot, somewhat adherent to the intima extending down into the radial for 2.5 cm., was extracted. Again, when the artery was closed and the compression released pulsations could be palpated in the radial at the wrist for sixty to eighty seconds, following which they disappeared. The artery was reopened and the clot again removed with the same result. Postoperatively both hands were fairly warm but no pulsation of the distal vessels could be discerned on either side.

For the next two days the arms and hands continued to have a fair color and, with the assistance of external heat, a moderate amount of warmth. At this time, in the absence of suitable pavaex apparatus, the arms were alternately inserted into the Drinker respirator for babies, the right arm being given treatment for two hours and the left for one hour out of every three.

Four days postoperatively, the color and warmth of both hands were greatly improved and on the left were practically normal. On this side a radial pulse could be felt though none was present on the right. However, the patient was able to move the right hand though she still complained of slight pain in this arm. This pain disappeared in the next three days, but pulsations did not return to the right radial up to the date of discharge December 15, 1935, twenty-seven days after operation.

Alternate suction and pressure were continued in the out-patient department. The right pulse became perceptible first on April 8, 1936, almost six months postoperatively. Meanwhile the patient experienced decreased sensation in the right hand which gradually was reduced to the fourth and fifth fingers by July.

Additional occurrences of significance consisted of a transient hemiplegia in January, 1937 and another more severe attack the following December. The woman was last seen on January 5, 1939, with good circulation in both arms, good pulsations in the left arm,



poor in the right, and partial recovery from her hemiplegia.

CASE II. A boy of 10 (F. W.), was admitted June 25, 1937 with acute osteomyelitis of the left femur and left humerus and staphylococcus septicemia. He was seen in consultation on July 3 because of cyanosis, loss of normal warmth and pulsation on the left forearm, occurring after incision and drainage of osteomyelitis of the left humerus. The brachial pulse could be felt down to the antecubital space, at which point it disappeared and a slightly firm enlargement of the artery could be felt. Operation was advised and embolectomy was done by the Carrell technique, approximately three hours after onset. Pulsation of the radial and ulnar followed release of the compression for about two minutes, but then decreased and disappeared.

Passive vascular exercise was applied immediately after operation and some improvement could be noted in the course of the next twelve hours.

In spite of blood transfusion, bacteriophage, staphylococcus antitoxin in large doses, and supportive measures, the patient died four days after the occurrence of the embolus. With intermittent use of passive vascular exercise the circulation of the left arm improved for three and one-half days although pulsations did not return. For the last eight to ten hours before death from the septicemia and multiple new foci in other bones, joints and the kidneys, the circulation of his arm again showed signs of failing, possibly due to the general circulatory collapse, although it was more marked in the left arm and hand than in the other extremities. However, no gangrene had occurred at the time of death, as proved by post-mortem examination.

CASE III. P. C., a woman of 47 years, was admitted March 34, 1938 on the Service of Dr. W. W. Babcock. She had suffered for twenty years with rheumatic heart disease with frequent attacks of fibrillation and on one occasion there was evidence of left cerebral and splenic infarction. Seven and one-half hours before admission she had suddenly developed terrific pain in the pelvis and lower extremities which later became paralyzed. Examination showed the lower extremities to be anesthetic and cold, and the vessels were considered to be moribund. Immediate operation was done by Dr. Babcock, opening both

femoral arteries to remove by retrograde extraction the clot that was straddling the bifurcation of the aorta. However, a very weak flow of blood on the right and a moderate flow on the left were the best that could be obtained. When the arteries were closed, pulsations rapidly diminished and ceased by the time the wounds were sutured.

In the course of the next thirty-eight hours the legs became increasingly mottled and dark, bullae formed over the skin, and gangrene was apparently impending. The patient expired thirty-eight hours after operation. No autopsy was granted.

#### SUMMARY

1. A brief review of acute arterial occlusion of the extremities is presented.
2. Recent advances in treatment are outlined and compared statistically.
3. Three cases of arterial embolus, one of them simultaneously bilateral, are presented.

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# SURGICAL TREATMENT OF VARICOSE VEINS AND ULCERS BY SEGMENTAL SCLEROSIS\*

WITH A DISCUSSION OF THE EFFECT ON PERIPHERAL ARTERIAL DISEASE AND THE  
GENERAL CIRCULATION

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IN a discussion of surgery of the extremities, the surgical therapy of varicose veins deserves consideration, not only because of the large number of affected people and the resultant disability, but also because of the newer concepts of treatment. Entrance of women into industry and athletics, wider adaptation of the causal relationship factor in compensation cases, and the recognized failure of injection therapy to effect a cure, have refocused attention on the varicose vein problem. A combination of the ligation and injection methods previously developed for the treatment of varicose veins, with the physiologically correct location of the ligation point at the saphenous-femoral valve and the even distribution of larger amounts of more effective sclerosing solutions, has improved the chances for a cure.

Without needlessly repeating the recent historical reviews of the varicose vein problem, we may mention that in the past the work of Valjean, Paré, Howe, Schede and Trendelenberg was particularly important, while C. H. Mayo and Babcock, with their vein stripping procedure, Homans, De Takats, and Faxon, have more recently contributed to the surgical progress. Injections date back to Pravoz, who first invented the syringe in 1851 (and used perchloride of iron), but it was the more recent work of Sicard and Linser, Zirn, Troisier with McPheeters and De Takats, as well as Higgins, Cattell and Rodgers that popularized the chemical oblitative treatment.

Varicose veins may be of congenital or acquired origin. The *congenital factor* is well illustrated by one patient we have seen, now under treatment, whose father died of the complications of an ulcer, and whose 12 year old son already has many dilated veins. The congenital absence of part or all of the valves in the superficial venous system is occasionally observed. One of our patients (T. F., age 11), with a "blow-out" at each communicating branch outlet, presents an instance of the absence of valves in communicating veins, proved at operation and on pathologic section.

Pressure congestion is a factor in the *acquired* type of varicose veins, of which pregnancy is an illustration. Probably as long as women have babies they will have varicose veins. The pressure on the iliac vessels during the last few months of pregnancy and in labor is the precipitating factor, but the number of women who bear children and still develop no veins testifies to the precept that in each instance there is an underlying valve or vein wall weakness. In addition to pregnancy, post-partum or postoperative phlebitis is a precipitating factor. Long hours of standing in such occupations as those of policemen, clerks, auctioneers, elevator operators, etc., as well as the use of machines with foot or thigh pedals, may produce varicose veins, but there is probably an underlying weakness of the vessels. The muscular action of walking tends to empty the veins and therefore occupations in which persons walk considerably do not frequently produce vari-

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cosities. Between 2 and 3 per cent of all patients admitted to general hospitals have pathologic veins, and of this group approxi-

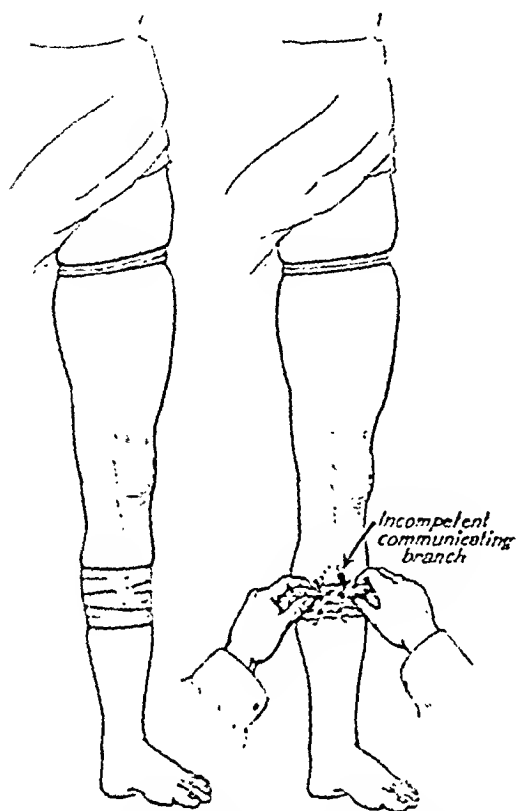


FIG. 1. Author's two tourniquet test for incompetent communicating veins. Tourniquet at upper thigh and a wide cuff below. This is rolled to its center until area of "blow-out" is demonstrated.

mately 65 per cent are complications of pregnancy. While many clinics present a marked difference in ages of the male and female groups, attributable to the pregnancy factor, our clinic draws from a poor district where patients neglect themselves and our age difference is negligible (male—41 years; female—40 years). The average period during which the patient had suffered from varicose veins before applying for treatment in our service was twelve and one-third years.

A study of the anatomic-pathologic process is of importance in understanding the condition. In the leg we have a deep femoral and a superficial, or auxiliary venous system, consisting mainly of the saphenous tree with communicating branches

to the deep veins. The deep veins are well supported by large, mobile muscles and seldom develop varicosities or incompetent valves. The superficial system is without perivenal support, has smaller branches and is subject to trauma. The valvular system normally maintains a distal-proximal flow through the superficial system, collecting the blood in the great saphenous vein and emptying it into the femoral at the fossa ovale. Failure of the valvular control, especially of the saphenofemoral valve, causes a reverse flow of the blood in the superficial tree, with stretching and loss of tone of the vein wall. The femoral vein blood flows through the incompetent saphenofemoral valve and produces a stagnated, congested, superficial tree: the blood drained from the extremity by the femoral, returns to the extremities through the failing valve before it has been aerated. A vicious cycle then develops; deoxygenated blood continually bathes the lower extremity and a condition conducive to swelling, induration, dermatitis and ulcer formation develops. At times the valves of the communicating branches do not function and there is a back flow from the deep system at the communicating points, with a so-called "blow-out."

The therapeutic problem is to eliminate the permanently incompetent superficial system and force the venous drainage of the limb through the deep, well supported femoral venous system. Palliatively, this may be accomplished by elevation and bed rest, the use of a rubber stocking, or supporting bandages. With the advent of modern injection therapy of safer sclerosing solutions, it was thought that the therapeutic problem was settled. Quinine and urea solution (Genevrier), sodium salicylate (Sicard, 1918), bichloride of mercury (Hempel), the various concentrates of sugar, sodium morrhuate (Higgins and Kittel) and more recently, sodium ricinoleate (Froelich and Henrickson) and other fatty acid salt solutions, accomplished surprising results. These effects were short lived, however, and while some varicose

veins, without a positive Trendelenberg test, respond well to simple injections, it is now recognized that when the saphenous-femoral valve is incompetent, permanent results from injections alone cannot be expected. The back pressure of the reverse flow will cause recanalization, and recurrence. Forty to 60 per cent of patients after injections return with the same symptoms and open veins can be demonstrated, by needling, in 100 per cent (in twenty-nine months, according to Howard). Injection failure led to efforts to revive and simplify the operative procedures. Hippocrates had ligated the saphenous vein. Trendelenburg, with his operation of a simple ligation considerably below the saphenous-femoral opening, corrected 50 per cent. Schede's circumcision at the junction of the middle and upper third of the thigh followed and these procedures, like others, failed in a large percentage because the underlying pathology of valve incompetence directly at the saphenous-femoral junction was not recognized and treated. De Takats, Ochsner and Mahorner, Johnson, Lowenburg, Edwards, McPheeters, Howard, Cattell and Sedwitz, are a few of the many workers who reported outstanding results with the combination of ligation and retrograde injection. Many logical advances have been reported and we feel we may add to these records.

At present the saphenous vein and its branches are divided directly at the fossa ovale, a section of vein resected and the vein retrogradely injected by a sclerosing solution, with localization of the solution at multiple points. Only two absolute contraindications are considered: closure of the deep veins by previous thrombosis and the presence of an acute phlebitis.

*Preoperative Preparation.* A careful history is recorded and a complete physical examination made, including pelvic and rectal investigation, in an attempt to find the underlying cause of the dilated veins. The arterial supply to the part is determined by inspection, palpation and oscillometric readings. While we no longer

consider defective arterial supply a contraindicating factor to the procedure, the condition of the arteries guides the amount of sclerosing solution.



FIG. 2. Section of vein through injection point, two weeks after sclerosing injection. The wall and vein contents have been replaced by fibrosis.

Certain venous tests are performed:

1. The patency of the deep veins is assured by a simple modification of the original *Pertbes test*, which is carried out as follows: The leg is elevated and a tourniquet is fastened around the upper thigh with sufficient pressure to close off only the superficial veins. The patient then walks for five minutes. There will be pain at once and marked swelling of the leg and ankle if the deep veins are closed, since the superficial venous return has also been shut off.

2. The competency of the saphenous-femoral valve is then determined by the *Trendelenberg test*. The tourniquet is placed near the fossa ovale on the elevated leg and the patient stands up. When the tourniquet is removed, rapid filling from above down, indicates an incompetent saphenofemoral valve (Trendelenberg, positive).

3. To determine if ligation at a "blow-out" point is indicated, a new *two tourniquet test* is used, as follows (Fig. 1): After

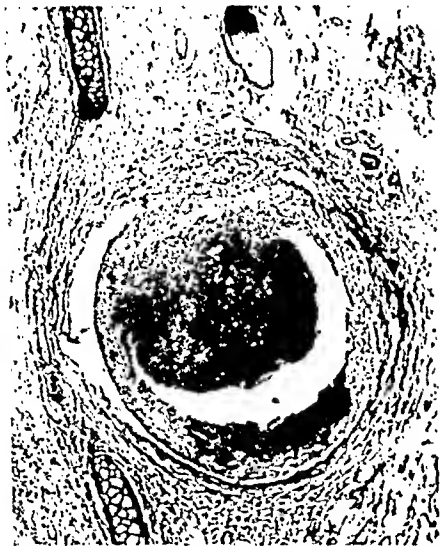


FIG. 3. Same vein  $1\frac{1}{2}$  inches from injection point. Notice separation of fibrotic area from wall with incomplete lumen closure and capillary spaces conducive to recanalization.

emptying the superficial venous tree, a tourniquet is applied near the fossa ovalis to control saphenous-femoral back flow, and a second, wide tourniquet cuff is placed on the lower leg. With the patient standing, this wide tourniquet is rolled toward its center until the point of the leak from the femoral through the communicating branches is ascertained. This "blow-out" area will be the point of the saphenous vein also requiring ligation. The location is measured from the patella. Experience shows that this occurs most frequently one hand's breadth below the patella.

**Surgical Technique.** The patient is prepared simply by a soapsuds enema, a  $\frac{1}{2}$  per cent lysol douche in the female, and careful green soap cleansing. Iodine and alcohol are used for skin sterilization.

The fossa ovalis is marked by the one-by-one rule: 1 inch below the spine of the pubis and 1 inch lateral. Other methods of determining this fossa ovalis, as by the percussion reflex test (McPheeters), marking by vision when standing up, and palpation of the femoral artery and taking a point just

medial to it (applicable only in thin individuals), have been found unnecessary, as even in an obese patient, the spine of the pubis can be readily felt and this simple rule invariably is sufficient.

Eighty to 100 c.c. of 1 per cent novocaine are injected radially, like the spokes of a wheel, from one single puncture at the fossa ovalis. Possible injection of large vessels is prevented by keeping the needle constantly moving, guiding it with the other finger on the skin and occasionally drawing back on the syringe. Only local anesthesia is applicable because we desire to have the patient walk immediately after the operation.

The incision is made 1 inch below and parallel to the inguinal ligament, with the medial end of the incision at the fossa ovalis, and is carried down through the superficial fascia. The saphenous vein is located by blunt dissection, its diameter measured in centimeters and a ligature guide passed around it. It is then dissected free to the femoral junction and the three most constant branches, the superficial external circumflex iliac, the superficial external pudendal and the superficial inferior epigastric, and any other anomalous branches divided and ligated with catgut. The superficial femoral cutaneous veins are not ligated. The saphenous vein is then divided at the femoral junction, the proximal end secured by a transfixion suture of catgut, and the distal end resected after dissection for a distance of 2 to 5 cm. The distal end is then opened and a ureteral type of catheter introduced for a distance of 40 to 60 cm. The introduction of the catheter is technically simple, as it slips by the valves with only a slight pressure, or twist. The injecting solution is then introduced as the catheter is withdrawn, 5 c.c. at a time, thus providing an even diffusion of sclerosing solution throughout the venous tree. The importance of introducing the sclerosing solution uniformly at different levels cannot be overemphasized. The sclerosis varies indirectly with the distance from the point of injection, and by making the points of injection close together, the

degree of sclerosis can be kept uniform throughout the vein.

To emphasize this point, photomicro-



FIG. 4. Same vein 3 inches from injection point without fibrosis or intimal change, demonstrating how localized is the sclerotic effect.

graphs are presented showing how localized is the effect produced by a sclerosing agent. Figure 2 shows the sclerosis at the point of injection of an animal's vein, with marked intimal destruction and replacement of the canal and blood by a fibroblastic proliferation. Figure 3 shows the same vein at a point  $1\frac{1}{2}$  inches from the injection point, with very little fibrosis and some capillary spaces, which are conducive to recanalization. Figure 4 shows the same vein 3 inches from the injection point, with no fibrosis and no intimal changes. This demonstrates how rapidly the sclerosis fades out as we move away from the injection site. This is obviated by the equal distribution of the points of maximal injection intensity throughout the vein length by the catheter. Fibrosis is more nearly complete and obliteration pathologically effective.

Figure 5 shows the catheter in the saphenous vein. The solution is injected as

the catheter is withdrawn. The patient then walks around the operating room for several minutes, after which an ace band-



FIG. 5. Catheter inserted in saphenous vein retrogradely. The sclerosing solution is to be injected as the catheter is withdrawn.

age is applied from the toes to the knee, including the heel. Any markedly discolored areas, indicating collection of sclerosing solution in dilated veins, are supported by pressure pad dressings. Walking is encouraged thereafter.

*Amount of Solution.* It was apparent when we started our study that large amounts of sclerosing solution would be necessary if we desired a complete saphenous vein sclerosis. Such solutions as sodium morrhuate, with toxicity at 5 c.c. doses, were thus eliminated. After considerable experience we determined that sodium ricinoleate ( $3\frac{1}{2}$  per cent) could be

utilized in the large amounts we desired. We obviated the local reaction which would follow such an injection through



FIG. 6. Incision at fossa ovale. Saphenous vein divided at the femoral junction. Branches (superficial inferior epigastric, superficial external pudendal and superficial circumflex iliac) ligated. Catheter tied into distal end, preparatory to injection. Automatic spring retractors adequately expose the field without the obstruction of hand retractors in the small incision.

equal distribution of the injection points by the catheter method.

Due to the variation in the size and branches of the saphenous vein, the necessary amount of sclerosing solution may vary. A large vein necessarily requires more solution than a smaller one, due to greater dilution by the blood and to greater intimal wall surface. We have developed a formula which gives us a fairly accurate criterion of the amount needed for each injection. The measured width, in centimeters, of the saphenous vein at the fossa ovale and the length, in centimeters, from the fossa ovale to the internal malleolus, divided by three, calculates grossly the amount of  $3\frac{1}{2}$  per cent sodium ricinoleate necessary:

$$\frac{\text{Diameter saphenous} \times \text{length saphenous}}{3} = X \text{ (amount of } 3\frac{1}{2} \text{ per cent sodium ricinoleate (in c.c.))}$$

We have used as much as 60 c.c. of the  $3\frac{1}{2}$  per cent solution, although the average amount is 40 c.c. This figure is a rough one, applicable only to  $3\frac{1}{2}$  per cent ricinoleate and is used merely as a guide. Additional factors such as the condition of the arteries, the presence of ulcers, the general condition of the patient, etc., are important and must be considered when using this formula. Other preparations need further trial.

The injection completed, the distal end of the vein is transfixed and ligated with o catgut and the wound is closed, without drainage, with silkworm gut or interrupted fine No. 35 or 36 alloy steel wire. The wire is valuable if there is any wound reaction, as there is no tissue reaction to the steel, and it can be left indefinitely, even if there is drainage. The location of the wound near the scrotum or vagina makes it susceptible to infection and this is counteracted during the operation by placing the incision lateral to the fossa ovale and retracting the wound medially, and also by a careful sealing of the area after the operation. A compound tincture of benzoin dressing is applied and sealed with liquid adhesive and adhesive tape, amply painted with white shellac to make it water tight.

When indicated by the *two tourniquet test*, a second incision is made over the point of leak from the deep system into the superficial system and the vein divided and ligated with catgut at that point. Approximately, one-half of our patients require this second incision.

Formerly, in agreement with most clinics, we considered a defective arterial supply an absolute contraindication to vein therapy. After considering the physiology of osmotic pressure and capillary pressure, it seemed, theoretically, that if the venous pressure became higher with varicose vein stasis, there would be increased venous capillary pressure. Consequently, there would be increased tissue pressure against which the arterial capillaries must work. With decrease in the venous pressure and lessened edema, it seemed apparent that arterial flow should improve. On this basis, this



procedure was tried on a patient (J. S., age 55) with advanced arterial occlusion, who had claudication after one-half block. His moderately enlarged veins were eliminated by ligation at the saphenous-femoral valve and by retrograde sclerosis. The result was quite startling: the patient was able to walk five blocks. In a second patient (K. S., age 64), in whom amputation was being considered for a marked arterial sclerosis with a trophic ulcer on the dorsum of the foot, obliteration of the associated veins was followed by prompt and permanent (one year) healing of the ulcer and relief of the pain for which the patient was receiving morphine. The same venous therapy in an individual (H. S., age 34), with severe thrombo-angiitis obliterans and a chronic ulcer, closed the ulcer and gave the patient his first relief from pain—pain which had been severe enough for him to attempt suicide. Four other patients have been clinically improved and, while laboratory proof of the improved vascular supply is difficult to present, the clinical evidence is very encouraging.

In one instance of tricuspid insufficiency, with a pulsating saphenous vein, the ligation and elimination of the vein have resulted in diminution of the valvular bruit and relief of cardiac decompensation. Further studies are being made, but clinically it seems that the removal of chronic, stagnant, venous pools, against which the heart must pump, improves the general circulation. This blood load, like the pulmonary edema of heart failure, or the peripheral edema of chronic nephritis, raises the peripheral resistance and increases the cardiac effort necessary to maintain adequate circulation.

While detailed statistical reports are not intended in this discussion, we have operated on approximately 100 individuals since adopting this technique twenty months ago. Two-thirds of our patients have had ulcers and in only two cases the ulcer has not closed. Both of these patients had heavy, brawny legs, with deeply set saphenous veins, and a subsequent modi-

fied Schede operation has demonstrated an incompetent venous shunt from the saphenous to the femoral vein, just above the ulcer. One out of every three of our patients had the operation performed bilaterally. There have been no deaths in the series and no serious complications. There have been two instances of general reaction to the drug, manifested by urticaria, low grade fever and general malaise, but the symptoms were mild and subsided in a few days. The majority have a febrile reaction for two to four days and evidence of a chemical phlebitis. In two patients there was a leak through the vein wall in the lower thigh with a small area of necrosis, but these areas healed in the course of four weeks.

The question of deep vein sclerosis is always considered when chemical obliteration of the saphenous vein is discussed. While the solution theoretically may run into the deep vein by the communicating branches, the excellent valves and perivenal support, with lack of stasis in the femoral vein, makes sclerosis unlikely. The catheter method, with its constant movement through the vein course, would tend to limit the amount of sclerosing solution which might enter the deep system.

#### SUMMARY

1. The anatomic-pathologic cause for varicose veins is discussed.
2. Selection and preparation of patients for saphenous vein ligation and sclerosis is detailed.
3. A new test for determining accurately the site of communicating branch incompetency is shown.
4. A technique which equally distributes the sclerosing solution throughout the vein length is presented.
5. A method to act as guide in computing the amount of sclerosing solution, when using sodium ricinoleate (3½ per cent) is included.
6. The possible advantages of obliterating varicose veins when there is defective arterial supply is suggested.



7. The effect on the general circulation is stressed.

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# GAS GANGRENE

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THE treatment of gas bacillus infection of the extremities has become increasingly more complex since Roentgen therapy and sulfanilamide have been reported to be of value. The response of the profession of these two newer forms of therapy may be overly enthusiastic. Over enthusiasm is not infrequent when a new product or form of treatment has been introduced. We are always searching for a panacea and are too ready to place ultimate faith in it, forgetting or discarding the older methods that have withstood the clinical test of past years. As time passes the pendulum returns. We begin to find our panacea either worthless, of definitely limited value, or to be used in conjunction with our accepted methods.

## HABITAT AND BACTERIOLOGY

Gas gangrene is produced by anaerobic bacilli and occasionally by aerobes. Twenty-five of the former and ten to fifteen of the latter have been isolated. The most common anaerobes are: *Cl. welchii*, *Cl. oedematis maligni*, *Cl. novyi*, *Cl. sordelli*, and *Cl. histolyticus*. Of the aerobes *B. coli* and the streptococci are the most common.

The anaerobes are widely distributed. They are found as natural inhabitants of the soil, of the intestines of human beings and of most herbivorous animals. They have been also isolated from samples of milk, spring water, shellfish, cheese, flour, wheat, barley, rice, oatmeal, gun wads, wool, air, canned sausages, potatoes, etc. These organisms have even been cultured from the mouths of newborn infants, normal salivary glands, from the pancreas, normal urine, and from the vagina. Considering the frequency with which these

organisms are encountered in wounds occurring in civil surgery it is remarkable that the incidence of gas infection is not greater than reported. The cause of this infrequency is not known. It may be due to the fact that gas bacilli per se do not produce gas gangrene.

Experimentally, gas gangrene can be produced in the pigeon with only a washed culture of *B. welchii*. In other experimental studies on animals the investigators have found difficulty in producing the infection unless the intramuscular injection of *B. Welchii* is accompanied by calcium or some other foreign material. The exact nature of this action is not known. Vincent and Stodel<sup>1</sup> showed that in guinea pigs *B. perfringes* and vibron septique injected separately produced no ill effects. When the two were injected in combination with *B. sporogenes*, gas gangrene was produced.

The pathologic studies of McNee and Dunn<sup>2</sup> were particularly enlightening in relation to the spread of gas gangrene into living and healthy muscle with intact blood supply. These authors emphasize the fact that gas gangrene starts at the site of the injured muscle and that extension of the gangrene is longitudinal within the muscle fibers. The fascial tissues tend to act as barriers to this spread. Anaerobic organisms were found distant from the active area of gangrene; it was therefore concluded that the toxin liberated by the organisms in the wounded muscle caused death of the adjacent muscle fibers. These devitalized muscle fibers were then invaded by the anaerobes, producing gas gangrene. The spread of gas gangrene in muscles whose blood supply had been impaired or occluded differed in that massive gangrene usually ensued.

Weinberg<sup>3</sup> classifies the gas bacilli into two groups: (1) saccharolytic and (2) proteolytic. The latter appear to thrive only after one of the former has destroyed the muscle tissue, thus preparing it for invasion. The proteolytic bacilli are supposedly responsible for the characteristic odor of gas gangrene.

#### DIAGNOSIS

Gas gangrene should be anticipated in all grossly contaminated wounds in which there is marked devitalization of muscle tissue. The first symptoms are excessive swelling and evidence of circulatory impairment of the part, pain out of proportion to the injury received, and an elevation of the temperature and pulse rate. The pulse rate is usually more rapid than one would expect with the degree of elevation of the temperature.

The diagnosis of advanced gas gangrene presents little difficulty. There is mottling of the skin due to ischemia, a peculiar brawny discoloration probably due to hemolysis, and the typical odor of decayed meat characteristic of *B. welchii* infection. After gas has formed in the tissues to such an extent that it is clinically evident, the infection is far advanced. The outcome is largely dependent upon the time of diagnosis.

X-ray of the soft tissues involved is most helpful in early diagnosis. Given a case which within a few hours after injury there are symptoms of severe pain, excessive swelling, evidence of circulatory impairment, and a rapid rise in temperature and pulse rate, until a definite diagnosis is made, x-rays of the traumatized portion should be taken at six hour intervals. Rhinehart<sup>4</sup> has shown that radiologically a diagnosis can be made in as short a time as two and one-half hours as compared with twelve hours clinically; the longest radiologic time is seventy-two hours as compared with seventy-five hours clinically; average is 18.8 hours against 50.5 hours. The mortality in the two series reported by him was 18.2 per cent in the

cases diagnosed radiologically and 52.5 per cent in the cases diagnosed clinically. Because of the great prevalence of gas bacilli in wounds, bacteriologic diagnosis alone is useless. We must combine clinical, roentgenologic and bacteriologic findings before a definite diagnosis of gas gangrene can be made. In the past, many cases have been diagnosed clinically without bacteriologic confirmation. This we believe is due to the fact that in a large number of hospitals the only culture made was that for the *B. welchii*. This isolated search for *B. welchii* should not complete the bacteriologic study. Theoretically every suspected wound should be cultured for each of the twenty-five anaerobes which have been shown to produce gas gangrene; however, for practical purposes the culture for the five most common anaerobes—*Cl. welchii*, *Cl. oedematis maligni*, *Cl. novyi*, *Cl. sordelli* and *Cl. histolyticus*—will usually suffice. The roentgenologic diagnosis per se is not final, as atmospheric air in the tissues may be found after closure of certain wounds, also following hypodermoclysis and hypodermic injections when all the air was not removed from the tubing or syringes prior to the administration of medication. Because of these possible errors in making diagnoses by the aid of bacteriologic and Roentgen examinations, it is difficult to evaluate the results obtained in those cases diagnosed solely by these methods.

#### SURGICAL CONSIDERATIONS

The treatment of gas gangrene begins with surgical prophylaxis of the wound, prior to the onset of actual infection. This treatment consists in removing all factors essential to the growth of the anaerobic organisms.

In the past we may have relied too greatly on the use of antiseptics. As emphasized so forcibly by Mont Reid<sup>5</sup> in a recent paper on wound healing, antiseptics are to be used with considerable care. Wound healing should not be impaired by the use of antiseptics which are apt to irritate.

Nature accomplishes healing of a wound. The surgeon should aid, not hinder this process. In many clinics the treatment of wounds consists only of cleansing with neutral soap and water, followed by irrigation of a large amount of saline. Painting the wound with brilliantly colored tinctures has been discarded.

The resection of all devitalized tissue, the careful search and removal of foreign bodies, and the drainage of pockets and dead spaces are of paramount importance. This technique has lessened considerably the time of wound healing and decreased the period of disability. Bacteria, especially the anaerobes, find little encouragement in growth in viable tissue.

Bohler<sup>6</sup> considers the above procedure far more important than serologic prophylaxis. He emphasizes that rents in fascia should not be sutured, nor should lacerated muscles be sutured unless there is complete transverse division. He further advocates that the wound should be left open and thoroughly drained with rubber tubing. Bohlman, in Evacuation Hospital No. 8, A.E.F., found that only 3 per cent of the debrided wounds were complicated by gas gangrene although 29 per cent of these had clinical evidence of gas infection at the time of operation, as shown by positive culture.

Since Tanner's report in 1923<sup>7</sup> there have been many cases reported of gas infection complicating surgically clean amputations. These reports have been summarized by Eliason, Erb and Gilbert,<sup>8</sup> who found that the mortality rate was exceedingly high, 59 per cent for their entire group. In patients suffering from diabetes the mortality following amputation was 75 per cent. These complications may arise from contamination without or from infection within; that is, severing lymph channels which contain the anaerobic organisms.

In respect to the first, Wright<sup>9</sup> found that the incidence of gas infection in leg amputations increased if spinal anesthesia was employed for amputation. This fact he attributes to contamination of the

wound by evacuation of flatus and feces on the operating table and afterward in bed during first hours, secondary to the relaxation of the anal sphincters. To avoid this contamination he advised a dry perineal cotton pad covered by another cotton pad saturated with bichloride of mercury solution used during operation. The stump dressing should be covered with waterproof material to prevent contamination from postoperative fecal incontinence. Following these precautionary measures there has been a decrease in the incidence of gas infection in cases of amputation of the thigh when spinal anesthesia was employed. Wright believes that the higher incidence of gas infection in the diabetic stumps might be due to the greater prevalence of *B. welchii* in the feces of these patients, associated with the lowered tissue resistance.

Orr<sup>10</sup> feels that infection from within is through the lymphatic circulation. However, no means of combating this latter complication is known. A guillotine operation with non-closure of the stump might prove of value in such cases, where a positive culture is obtained from the gangrenous area preoperatively.

Reports of cases of gas gangrene following hypodermoclysis and hypodermic injections do occur. Fortunately this complication is infrequent. The causes of these infections are difficult to ascertain. They usually occur in the debilitated patient, and the mortality is high. Harney<sup>11</sup> reported eighty-six cases with a mortality of 88.4 per cent.

In the treatment of active gas bacillus infection the extent of the surgery performed must depend entirely upon the individual case. If the circulation of the extremity is unimpaired and the infection is confined to a muscle or group of muscles, wide excision of the involved muscle tissue is indicated. If the circulation of the part involved is impaired or if the muscle damage is so extensive as to involve an entire extremity, amputation is necessary. If the involvement is confined to the lower leg,

Coller<sup>12</sup> advocates disarticulation at the knee. If the thigh is involved, a guillotine operation above the site of the involved muscles is indicated. Eliason, Erb and Gilbert<sup>8</sup> have shown that a more conservative procedure, such as incision and drainage, will give better results than radical amputation in those cases in which serum or serum together with x-ray therapy was administered:

MORTALITY PERCENTAGE					
Serum plus X-ray		Serum		No Serum	
Amputation, Per Cent	Incision, Per Cent	Amputation, Per Cent	Incision, Per Cent	Amputation, Per Cent	Incision, Per Cent
42	7	22	13	26	37

Millar's statistics<sup>13</sup> also showed a 52.5 per cent mortality in radical amputation as compared with a 22.3 per cent mortality where incision and drainage were performed prior to amputation. There has been a great trend by surgeons to limit their surgery to the removal of the devitalized tissues or simple incision, not amputation unless the entire limb has been deprived of its blood supply. This method of treatment is recommended by the United States Army Medical Corps, which advocates further that the longitudinal incisions in muscles and fascia should be made half again as long one would deem apparently necessary. The results following this method of therapy are quite encouraging.

#### SEROLOGIC CONSIDERATIONS

The statistics evaluating the use of gas bacillus antitoxin prophylactically or therapeutically vary greatly; those of the World War show the best results. In evaluating these statistics of military cases one is mindful of the fact that the routine use of antitoxin and the routine employment of débridement were the method of treatment. However, Vincent<sup>14</sup> was most

enthusiastic over the use of serum, stating: "During the war not a single case of gaseous gangrene came to our knowledge amongst the numerous gravely wounded who had received the serum in preventive titration. In the field hospital where the injections could be made early, the protection assured by this method was particularly striking to all the surgeons who used it." Duval and Voucher<sup>15</sup> reported a reduction in mortality from 16 per cent to 3.5 per cent in those cases in which antitoxin from *B. welchii* and the bacillus of malignant edema was administered. Van Buren also reported the successful employment of this procedure among the British and American forces during the latter part of the World War.

The results following antitoxin prophylaxis since the war have not been so encouraging. As a result many surgeons have condemned its use. The cause of this failure may be due to an insufficient concentration of the causative organism. Although we were unable to find any experimental evidence to support the statement, it may be assumed that the employment of gas bacillus antitoxin should be similar to the administration of tetanus antitoxin. It has been shown experimentally that the antitoxin titer of the blood following a prophylactic dose of 1,500 units of tetanus antitoxin rapidly declines and is not detectable after two to three weeks. Therefore, in wounds where gas infection is anticipated gas bacillus antitoxin should be repeated with the tetanus antitoxin.

The function of antitoxin is to neutralize the toxin formed by the various gas-forming anaerobes. As stated previously, any one of the twenty-five anaerobes and ten to fifteen aerobes may produce gas infection. Therefore, if the antitoxin administered does not include the prevailing organism, naturally there would be no antitoxic effect on the toxin produced. Until recently it has been impossible to obtain truly polyvalent antitoxin. The antitoxin of Professor Vincent is perhaps

the most efficacious at this time. This antitoxin is prepared from twenty strains of species of bacteria commonly found in gas infection. This antitoxin is, unfortunately, very difficult to obtain in this country. Theoretically, a polyvalent antitoxin given in sufficient quantity to neutralize all of an unknown amount of toxin formed should relieve the patient of the systemic reactions to this toxin.

Collander, Haim and Maximov<sup>16</sup> advise as prophylaxis one minimal therapeutic dose of 10,000 units Welch antitoxin with 10,000 units oedematis maligni (vibrio septique), 200 units novyi (oedematiens), 200 units sordelli, and 25 units histolyticus. This prophylactic dose should be given to every patient with suspected gas gangrene and to all patients with gunshot wounds, wounds associated with devitalized tissue, compound fractures, and extensive burns. Penfold and Tolhurst<sup>17</sup> found that active immunity could be produced in mice by the use of *B. welchii* toxoid and they are now injecting humans with an alum precipitate of the *B. welchii* toxin. Their work is still in the experimental stage.

The value of antitoxin in the treatment of gas bacillus infection after development of symptoms is debatable. The consensus of opinion is that it should be given. Eliason, Erb and Gilbert<sup>8</sup> reported a 25 per cent mortality in 224 cases treated with antitoxin and a 49 per cent mortality in 125 cases treated without antitoxin. Millar's figures<sup>13</sup> were 39.4 per cent for ninety-nine cases treated with antitoxin and 42 per cent for 291 cases treated without antitoxin. Duval and Voucher<sup>15</sup> reported a reduction in mortality from 16 per cent to 3.15 per cent after the use of Weinberg and Seguin antitoxin. Vincent<sup>14</sup> stated that 85.9 per cent of patients who recovered from gas gangrene during the war had been treated with antitoxin. Everidge,<sup>18</sup> evaluating the use of gas gangrene antitoxin, states: "Personal experience leads me to believe that in many cases it alleviates the virulence of the infection and renders certain cases more

amenable to surgical procedures than would otherwise have been the case." Bates<sup>19</sup> reported a 50 per cent mortality in sixteen cases treated without antitoxin and a mortality of 18 per cent in sixteen cases treated with antitoxin. Ghormley<sup>20</sup> reported that 86 per cent of thirty-three patients recovered following the use of antitoxin.

As to the dosage of antitoxin, Callander<sup>16</sup> advises 100,000 to 150,000 units or more of polyvalent antitoxin to be given intravenously upon the first appearance of gas bacillus infection. We are inclined to agree with this author, feeling that if antitoxin is indicated it should be administered in sufficient quantity to combat the toxemia. The surgeon may then be able to treat the infected wound with conservative surgery instead of immediate amputation.

#### ROENTGENOLOGIC CONSIDERATIONS

Kelly,<sup>21</sup> in 1933, reported eight cases of gas bacillus infection treated with x-ray. Six of these were limited to the extremities, all of whom recovered. The failure of the two trunk patients he attributed to the fact that they received an insufficient amount of radiation.

In 1938,<sup>22</sup> Kelly further reported 143 cases collected from about 100 roentgenologists. Ten patients died as a result of causes unrelated to the gas infection. Of 105 patients suffering from gas gangrene of the extremities treated with x-ray, there was a 4 per cent mortality in the nonamputation group as compared with a 9.1 per cent mortality in those amputated. Kelly subdivides those requiring amputation into two groups: (1) where amputation is required because of the severity of the initial trauma (mortality 6.2 per cent); and (2) those who had therapeutic amputations performed when gas gangrene was first diagnosed (mortality 11.7 per cent). These statistics are extremely favorable and warrant consideration. However, in justice to the other forms of treatment (surgery and antitoxin) we must not lose sight of the fact that most of Kelly's cases were diagnosed

clinically and roentgenologically, without bacteriologic confirmation.

Erb,<sup>23</sup> using pure washed strains of *B. welchii* on pigeons, could not find any evidence of the beneficial effects of x-ray treatment when used as a prophylactic or therapeutic measure. Kelly, in 1936,<sup>24</sup> stated that he was unable to substantiate in guinea pigs the value of x-ray therapy. However, in 1938 he stated:<sup>25</sup> "In our animal experimental work we thought we proved conclusively that the earlier treatment was started the more easily it subsided; and if treatment was started late it seemed to have much less effect." There seems to be some change of opinion between Kelly's report in 1936 and 1938.

#### SULFANILAMIDE

Bohlman<sup>25</sup> reported three cases with cures of clinical gas gangrene following compound fractures of the lower extremity treated with sulfanilamide. However, all of these patients received serum prophylactically; therefore, one is unable to evaluate the effect of the antitoxin and the sulfanilamide.

Bliss and Long noted that experimentally sulfanilamide had a preventive effect in mice whose peritoneal cavity was injected with *B. welchii*. Their treated mice were injected with 1 c.c. of saline solution of sulfanilamide thirty minutes before being injected with a pure strain of *B. welchii*, was unable to demonstrate any beneficial effects with sulfanilamide orally administered. All of the injected pigeons died.

#### DISCUSSION

The fact that neither x-ray therapy nor sulfanilamide has proved to be of value may be due to the fact that in the experiments washed cultures of only *B. welchii* were used; that is, they dealt with a monobacterial infection. The beneficial clinical results of these two methods of treatment may be due to their known therapeutic

effect upon streptococci, which so frequently contaminate gas bacillus infections.

Gas gangrene resulting from the anaerobic gas-forming bacilli is self-limiting, as suggested first by Novak,<sup>26</sup> who states according to experience learned from the World War that the time of appearance of gas phlegmon after an infliction of a wound is as follows: first day, 21 per cent of cases; second day, 33 per cent of cases; third day, 15 per cent of cases; ninth to twentieth day, 1 per cent of cases. This fact is further corroborated by the findings<sup>27</sup> at Base Hospital No. 15, A.E.F., where the anaerobic death activity practically confined to the first seven days, with the death rate from the anaerobic infection alone was high but with a short period of danger to life. Many patients with gas gangrene died after the first week, not as a result of the gas bacillus infection alone, but from a rapidly accumulating toxemia resulting from the contaminating streptococci and staphylococci in the process of replacing the anaerobic organisms. A streptococcus bacteremia was the most common cause for death in the patients who survived the first seven days. With the streptococcus the principal cause for death after the first seven days, the use of x-ray and sulfanilamide should not be questioned as important adjuncts, as is serum, to appropriate surgery in the treatment of gas gangrene.

#### SUMMARY

Prophylaxis in gas gangrene consists of: (1) débridement and the thorough cleansing of early wounds; (2) prophylactic administration of polyvalent antitoxin in one minimal therapeutic dose in gunshot wounds, wounds associated with devitalized tissues, compound fractures and extensive burns.

Treatment of the active infection consists of: (1) incision and drainage of all pus pockets and dead spaces, and débridement with excision of all involved tissues; (2)



amputation only if the entire limb is involved in the infection or if the blood supply of the entire limb is impaired; (3) polyvalent antitoxin administered intravenously in dosage from 100,000 to 150,000 units if practical; (4) sulfanilamide and x-ray therapy for their beneficial effects on the contaminating streptococci.

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# DIABETIC GANGRENE—A CLINICAL PROBLEM

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IT is not our purpose to present an exhaustive study of diabetic gangrene, but rather to review the more practical aspects of the problems presented by the group of 559 patients whom my associate, Dr. Theodore C. Pratt, and I have seen at the New England Deaconess Hospital during the past sixteen years. For purposes of treatment the problem of diabetic gangrene is a clinical one. Practical evaluation of a given patient's circulatory background is based upon careful clinical examination; proper treatment consists in the application of the information obtained from this examination to the particular patient under discussion in the light of the surgeon's own experience and that reported by others.

The mortality following operations for diabetic gangrene in this country varies from 13 to 65 per cent.<sup>1</sup> Almost without exception hospitals reporting mortality in the higher brackets have with each subsequent report shown definite and marked improvement. This improvement has come not from the institution of newly discovered surgical procedures or new methods of therapy, but rather because some one or two surgeons have become interested in the problem, have reviewed their own hospital results, and have studied those of others. Increasing experience, closer coöperation with the medical service, careful surgery, and patient attention to detail have resulted in the saving of more legs, the loss of fewer lives, and a lessening of the economic burden which these patients place upon family and community.

## DIAGNOSIS

About one-half of the diabetic patients seen by us have adequate circulation to

their extremities and are not included in this discussion.

The diagnosis of gangrene of one or more digits in a patient with diabetes is not difficult. If in diagnosis, however, one includes a careful evaluation of the circulation to a given foot with particular reference to its ability to permit spontaneous separation or surgical removal of a gangrenous digit, the problem then becomes a more difficult one.

For practical evaluation of the circulation of the diabetic patients at the New England Deaconess Hospital we depend entirely upon a careful history and clinical examination. We depend upon neither special tests nor special instruments.

*History.* *Intermittent claudication* may or may not have been present. In some cases there may be a history of pain in the legs or feet after walking and relieved by rest, which was present months or years before and which gradually disappeared as the collateral supply developed. Or it may be of more recent origin and progressive to the time of examination. In many cases it is absent. *Attacks of numbness or pain*, usually of sudden onset, are frequently described and suggest one or more minor thromboses in the past. Such attacks frequently culminate in a more severe one which brings the patient to the hospital. *Rest pain* when present is of great importance. *Pain* is not a common symptom in lesions of the feet in diabetic patients except in the presence of a markedly deficient arterial supply. When it is either associated with an area of gangrene or without any open lesion it indicates a severe degree of arterial deficiency.

*Examination.* Both legs are bared to above the knees. The patient is flat in bed

with the heart and extremities on the same level. *Inspection:* Much information is obtained relative to the presence or absence of arterial deficiency by careful inspection of the feet. The better the circulation, the more nearly will the appearance of the feet approach that of a normal individual. Thin, parchment-like skin, with atrophy of the subcutaneous tissues, and dry brittle nails suggest the tissue starvation that is associated with inadequate arterial supply. Rapid blanching of the foot on elevation and slowly developing rubor or cyanosis on dependency is one of the most striking and constant findings in a foot with a poor arterial supply. Not infrequently one sees a foot which in the normal resting position is blanched and in which the superficial veins are collapsed. Such a foot is promptly recognized as one with extensive arterial disease and poor prognosis. It is important to note the upper limit of color change when the foot is dependent, since a major amputation, if necessary, must be well above this level.

*Palpation:* Temperature variations as elicited by the hand are sufficiently accurate for clinical purposes. The same levels on the two sides and different levels on the same side are carefully compared. Not infrequently one is surprised to find a definite level of temperature change in the upper third of the lower leg, with only a minor lesion on one of the toes. Such a level may or may not correspond with the level of color change and is indicative of extensive arterial disease and suggests a very guarded prognosis. Palpation of the peripheral vessels, the dorsalis pedis, anterior tibial, posterior tibial, popliteal and femoral arteries is of greatest importance. Of these the femoral and the dorsalis pedis vessels are most easily palpated and the latter is by far the most important. Failure to feel pulsation in this vessel, particularly if there is active evidence of arterial insufficiency, indicates advanced obliterative disease and warrants a cautious prognosis.

## PREVENTION

No discussion of diabetic gangrene is complete without a consideration of its prevention. A large number of patients in the sixth decade and over have obliterative arterial disease, many depending entirely upon collateral supply. Such patients may well remain free from gangrene indefinitely if a break in the skin can be avoided. Poor eyesight, absence of normal sensation to pain, heat, or cold, and a lowered threshold to tissue damage all contribute to the development of some minor injury which may result in the loss of a limb or a life.

Of greatest importance in the prophylactic care of the feet are:

1. Epidermophytosis. Without question secondary infection and necrosis arising in a small fissure between the toes is one of the most common precipitating causes of gangrene. The feet must be carefully examined for evidence of this infection.

2. Burns or blisters often follow the use of hot bricks, hot water bags, electric pads, new shoes, or wrinkled socks. *Never advise any diabetic patient to apply heat to a lower extremity.*

3. Care of the nails, calluses, and corns should be entrusted to one of experience in podiatry and understanding of the diabetic state. It may be done by an intelligent member of the family, but never by the patient.

## NON-OPERATIVE TREATMENT

In the earlier stages of obliterative arterial disease and for minor areas of gangrene it is the aim of non-operative treatment to (1) control infection; (2) relieve pain; and (3) stimulate the development of collateral circulation (or, as frequently happens, to readjust the circulatory needs of a foot to its arterial supply). These results we try to obtain by

1. Rest in bed with sufficient medication to control pain. It is imperative that the resting position of the involved foot be such

that the foot is not blanched (Buerger's angle of circulatory sufficiency).

2. Large warm packs of saturated boric solution, which are used to control a spreading infection.

3. Local applications, depending upon the local condition. The following medications have proved useful to us over an extended period of time: Dakin's solution; hexylresorcinol, solution S. T. 37 (1:4); azochloramide, 1:3300 in saline or 1:300 in triacetin; cod liver oil ointment; thioglycerol.

4. Careful hygiene of both feet, avoidance of pressure areas by the placing of a small pillow just above the heel, daily massage with hydrous lanolin, and careful podiatry.

5. Buerger's postural exercises<sup>2</sup> as modified by Allen<sup>3</sup> except in those cases with lymphangitis or spreading infection.

6. Intermittent venous compression as suggested by Collins and Wilensky<sup>4</sup> which has been used during the past six months and appears to have a definite place in the treatment of these cases.

7. General supportive measures such as iron for anemia, a well balanced diet, and high fluid intake.

#### OPERATIVE TREATMENT

*Indications for Operation.* 1. Gangrene. Gangrene in a pulseless, painful foot is an indication for amputation, unless it is superficial and limited to the tip of a digit and shows evidence of healing without pain at the end of three weeks' hospital treatment as previously outlined. Operation is also indicated for:

Gangrene of one or more toes involving the deeper structures of the foot in the absence of good pulsation in the dorsalis pedis artery, and

Gangrene of all or part of a digit associated with lymphangitis, a pulseless foot, and failure of the infection to disappear under careful treatment.

2. Pain without Gangrene. The painful, pulseless foot which is unrelieved after three weeks of hospital treatment has

insufficient blood supply to be of use and should be treated by amputation.

3. Osteomyelitis of a Phalanx. Osteomyelitis of a phalanx is an indication for operation. Any unhealed ulcer of two weeks' duration overlying or on one side of an interphalangeal joint is regarded as actual or potential osteomyelitis. A positive diagnosis can be made earlier by demonstrating bare bone with a small probe than by the use of x-rays. Osteomyelitis involving the tip of a phalanx in relation to the nail bed may heal without operation other than the careful removal of all or part of the nail.

*Selection of the Level at Which Amputation Should Be Performed.* In Table 1 are listed all of the operations which have been done for diabetic gangrene at the New England Deaconess Hospital between January 1, 1923 and January 1, 1939. Almost without exception any operation on the foot of a diabetic patient with gangrene will necessitate at least the removal of a toe. Excision of an area of gangrene or incision and drainage of a foot is indicated only in unusual conditions. During the past sixteen years it has been performed in this group of patients only eight times.

Decision as to the level at which amputation should be done may be easy or it may be very difficult. There are certain facts which should be taken into consideration:

1. The diabetic patient is usually as old as his age in years plus the duration of his diabetes.

2. Treatment by trial and error is extremely dangerous and usually unsuccessful.

3. Once gangrene has developed, the tendency to develop septicemia may be greater than the tendency to develop adequate collateral circulation.

4. Unless the patient's general condition is such as to permit the use of an artificial limb, there is no advantage in saving a knee joint.

5. A carefully done supracondylar amputation using a circular incision is a simple and safe operation, and in our own experi-

ence is followed by first intention healing in 93 per cent of the cases.

6. Faint pulsation in the dorsalis pedis artery is little or no better than no pulsation.

7. Successful amputation of one or more digits for gangrene in the absence of pulsation in the dorsalis pedis artery has occurred in only twenty-five\* or 12.5 per cent of the last 200 cases operated upon by us, and amputation of one or more digits in the absence of pulsation in both the dorsalis pedis and popliteal arteries has been successful in only three of the 200 cases.

*Amputation of a Toe.* Successful amputation of one or more toes was done in 9.3 per cent of all our cases operated upon for gangrene. It is usually safe and may be successful, providing there is no lymphangitis, for: (1) osteomyelitis of a phalanx without actual gangrene; (2) localized gangrene of the tip of a digit if there is good pulsation in the popliteal artery, if the foot is warm, of good color, and with no definite level of temperature change, providing the patient is not having severe pain after two weeks of hospital treatment; and (3) in the presence of good pulsation in the dorsalis pedis artery.

*Amputation through the Upper Third of the Lower Leg.* This may be safely and usually successfully done in a patient under 70 years of age who is in good general physical condition providing (1) there is good pulsation in the popliteal artery; (2) the skin at the level of incision is in good condition; (3) there is no temperature or color change above the ankle; and (4) there is no evidence of infection in the lymphatics or veins above the level of the ankle.

*Gritti-Stokes Amputation.* Such an operation should not be done for a diabetic patient unless the surgeon has had a good deal of experience with it. It does not have sufficient advantages over a supracondylar

amputation to compensate for the increased technical difficulties. It gives an excellent stump. It has the same require-

TABLE I  
OPERATIONS FOR GANGRENE  
1923 through 1938

Operations	No. of Cases	Deaths	Mortality, Per Cent
Amputation of one or more toes.....	56	4	7.1
Amputation of toe, then major amputation.....	40	4	10
Incision and drainage only....	8	0	0
Incision and drainage, then major amputation.....	3	2	66.7
Guillotine amputation.....	34	15	44.1
Lower leg amputation.....	37	2	5.4
Gritti-Stokes amputation.....	81	11	13.6
Thigh amputation.....	300	35	11.7
Totals.....	559	73	13.1
Toe amputations*.....	96	8	8.3
Major amputations*.....	495	69	13.9

\* It has seemed wise in presenting the final statistics to include in both these groups the forty patients who had major amputations following the unsuccessful removal of one or more toes.

ments as an amputation through the lower leg except that good collateral circulation around the knee is of more advantage than pulsation of the main vessel. It is particularly useful for a heavy man who will be on his feet for long periods at a time.

Callender's<sup>5</sup> modification of this operation has not been used by us, but has found much favor on the West coast and should be a much safer procedure than the more complicated Gritti-Stokes amputation.

*Amputation through the Thigh.* Supracondylar amputation is in our experience the simplest and safest operation. It is indicated for (1) a condition permitting primary suture but requiring the shortest and safest operation; (2) conditions that will prevent the subsequent use of an artificial limb, such as failing eyesight (not due to cataracts), mental instability, etc.; (3) inability to feel any popliteal pulsation, unless the skin is warm and of good color

\* This is in sharp distinction to the group of patients with good pulsation in the dorsalis pedis artery, where 136 or 68 per cent of the last 200 patients have had one or more toes removed successfully.

at least to the level of the ankle; (4) failure to palpate the femoral artery in the groin; and (5) extensive infection which makes lower amputation unsafe.

*Guillotine amputation* is restricted to (1) the patient with septicemia, actual or suspected, from a badly infected or gangrenous foot; (2) the very sick patient with extensive sepsis; and (3) the patient who has a gangrenous foot with extensive lymphangitis, in whose case primary suture would be unsafe.

#### ANESTHESIA

Spinal anesthesia, using 50 to 75 mg. of procaine hydrochloride, is our anesthetic of choice. Chloroform or avertin is too dangerous and should not be used. Ethylene-oxygen, cyclopropane-oxygen, or nitrous oxide-oxygen are preferred by some, but we believe it easier to learn to give a low spinal than a safe gas oxygen anesthesia.

#### TECHNICAL CONSIDERATIONS

The many details of technique in the preparation of patients for operation and of the operations themselves have been given in the past and need not be repeated here. Certain of the more fundamental principles may be repeated, however:

1. Circulation at the level of operation must be adequate to localize infection and permit repair to take place.

2. Drainage must be dependent and complete. A continuous incision is preferable to counter incisions.

3. Incisions must be so placed as to minimize interference with the blood supply and, at the same time, permit extension of the wound should further infection occur.

4. Whenever possible, amputation of a toe should be through the base of the proximal phalanx. If infection has extended into the foot, removal of the head of the affected metatarsal may be indicated and should be done through an extension of the same incision. The entire head and any sesamoid bones present should be removed.

5. Major amputations (except guillotine) must be done through good skin at a level of adequate circulation, though only very rarely above the supracondylar level.

6. We have used both fine silk and fine catgut for sutures and are unable to demonstrate any clinical advantage of the former. We feel that catgut, not heavier than No. 0 chromic, is preferable to silk in the hands of the average surgeon.

7. Guillotine amputation is usually done at or just above the fleshy part of the calf of the leg, rarely above the knee. The skin, muscle, and bone are cut in one plane. Boric or cod liver oil ointment dressing is applied and changed every three or four days. Re-amputation at a higher level, usually just above the condyles, is done after ten days or two weeks if a satisfactory response has been obtained. Guillotine amputation below the knee is the only amputation in which we feel free to use a tourniquet.

#### RESULTS

Six per cent of 138 patients who were treated for gangrene without operation at the New England Deaconess Hospital from 1935 to 1938 died from other causes, usually cardiovascular, during their hospital treatment. The mortality of all operations in 559 patients was 13.1 per cent, that for major amputations being 13.9 per cent. The difference between the 6 per cent mortality in the non-operative group and the mortality of those operated upon represents the mortality of delay, improper selection of operation, or technical error. We cannot urge too strenuously the careful study of the individual patient, painstaking attention to detail in the minor as well as major surgical procedures and, above all, early and prompt amputation as soon as the indications are definite.

#### SUMMARY

The clinical problems presented by the 559 diabetic patients operated upon for gangrene have been reviewed.

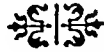
The indications for major and minor amputation are discussed.

The mortality following major amputations in 495 patients has been 13.9 per cent.

The mortality following primary supracondylar amputations in 300 cases has been 11.7 per cent.

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YESTERDAY'S meals are forces that shape today's fate and tomorrow's destiny. It was a slender Napoleon that won the world at Austerlitz and a fat Napoleon that lost it at Waterloo. The battle won on the playing-fields of Eton was lost at the dinner tables of Versailles.

# PROBLEMS OF PAIN REFERENCE TO THE EXTREMITIES\*

## THEIR DIAGNOSIS AND TREATMENT

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PAIN arising in the extremities or referred to them may be caused by a large number of conditions. From a practical clinical standpoint, the recognition of the cause and the solution of the problem usually depend upon a clear understanding of a few important fundamentals concerning the pain mechanism, its origin, purpose and pathways, as well as the type of pain complained of and the type of individual suffering the pain.

First of all, the patient must be able accurately to describe the sensation of pain, discomfort or suffering in definite terms which remain identical upon repeated questioning. Vague and variable references will only lead the examiner astray.

Secondly, the patient must trace, localize, give the direction of, or carefully indicate (with one finger if possible) exactly where the pain seems to be. This part of the examination must be repeated until it is certain that patient and examiner alike are agreed upon its location and extent.

Thirdly, the character of the pain must be carefully considered in regard to intermittence, nocturnal or diurnal qualities, factors concerned with exacerbation or relief; if possible the clinician must try and establish its predominating quality so as to permit its classification into one of the three following groups:

- i. Sharp, stabbing, shooting, lightning-like, cramp-like, etc.
- ii. Burning, scorching, tingling, etc.
- iii. Dull, aching, throbbing, boring, pressure-like, etc.

In group i the violent sharp, stabbing-like pain may be considered similar to that experienced when a nerve in a tooth has

been touched by a dental instrument. The true neuralgias are immediately detected in this category and this type of pain usually indicates intrinsic involvement of the nerve or its roots.

In group ii the sensation of burning is similar to that experienced when salt is introduced into an open wound or the character of tingling noted when a nerve has temporarily recovered from what is termed "going to sleep." The causalgias belong in this division, and although they may vary greatly as to degree, if they are carefully described there is little difference between the many kinds. This type speaks compression, mild traumatic injury, recovery from severe trauma, or constriction by adhesions along the nerve or its roots.

Group iii gives rise to a dull ache like that encountered in a bruised shin bone, the swelling after trauma, a throbbing headache, etc. This type indicates a vascular pain mechanism and is commonly associated with some distention or stretch of the arterial and capillary network of vessels, as well as stretch of the peripheral pain network. It usually is associated with some process of inflammation, hyperemia, swelling or edema.

In some instances two or three of these groups may be combined so that the additional time spent in questioning the patient and rechecking each detail of his story for accuracy will indicate the degree of complexity of the problem or perhaps save the examiner the confusion and dismay that accompanies the final discovery that the patient really was distressed with a "feeling of pressure rather than pain" or that the exaggerated and inaccurate statements

\* From the Neurosurgical Service of the Temple University Hospital.

of the psychalgic patient had led him astray because they had been allowed to stand unchallenged.

visualize clearly the pain structure and its pathways. This is not difficult when we realize that the pain mechanism is the most

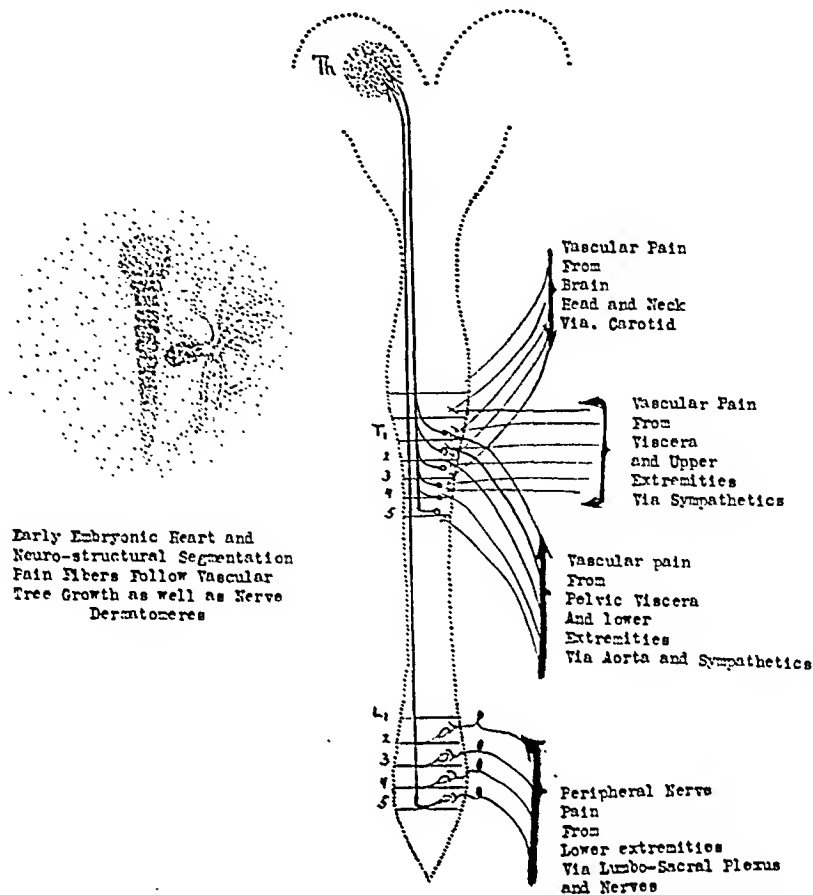


FIG. 1. Diagrammatic representation of vascular pain mechanism and its area of entry into the spinal cord. The proximity of the embryonic heart and vascular pattern to the developing segmentation of the nervous system probably accounts for the convenience of these fibers reaching the spinal cord between the first and fifth thoracic segments. This gives rise to two pain mechanisms which require individual consideration in pain problems, especially those associated with the lower extremities and the thoracic viscera.

Patients with pain demand sympathetic understanding and treatment. Nevertheless, the clinician must be constantly on guard lest he misinterpret the symptoms and, having been misled, finally fail of a diagnosis or resort to unjustified narcotics to give relief.

I consider the above approach to the problem the most important phase of the examination because it not only suggests the probable location and character of the lesion from the pain structures involved, but establishes the emotional aspects and reliability of the patient as well.

The next important consideration when dealing with a mechanism of pain is to

primitive of the sensory family. There are no differentiated end organs, merely a fine gauze-like network of fibers that is spread over the external surfaces of the body for the purpose of warning and protection, and over the capsules of certain organs as well as the arterial coats and to some extent the large venous sinuses.

In the early development of the embryo the heart and vascular pattern are first to arise along with the somites and the neural tube. (Fig. 1.) As a result, the pain fibers which are phylogenetically the most primitive, reach their destinations over two chief systems or pathways: (1) the segmented spinal peripheral nerves and certain cranial



## Fay—Pain Reference

nerves; and (2) the vascular tree. For instance, the parietal peritoneum is supplied with pain fibers from branches persist even after complete destruction of the peripheral nerves and their roots, even when complete superficial anaesthesia ex-



FIG. 2. The upper illustration shows the burette elevated above the level of the lumbar needle; the system is tested to determine whether or not a free flow of spinal fluid occurs out of the lumbar needle. Note the level of fluid in the burette and the pinch clamp for closing the system. The lower illustration shows the burette lowered to the desired level. The upper level of fluid in the burette is on a plane with the highest point of anesthesia required. The anesthetic is introduced through the lumbar needle as the column of fluid descends. (From Fay, in *Arch. Neurol. & Psychiat.*, 30: 1278, 1933.)

of the segmental spinal-peripheral system, whereas the visceral portions, including the gut tube and certain organs, receive their pain supply from the vessels, along with fibers through the large sympathetic plexuses. Pain from the former can be controlled by dealing with the segments involved; pain from the latter requires an entirely different attack upon the fibers that find entry into the spinal cord in the upper thoracic area.

Before taking up certain frequent peripheral pain problems, one may cite here the all too frequent problem of painful so-called "amputation neuroma" of the lower extremity, the symptoms of which may

ists. Here the pain persists because the vascular pathway remains open from the level of the amputation through the iliac artery and aorta to the high thoracic cord. Complete relief of pain in such cases can be obtained only by *chordotomy* (Spiller operation) of the anterolateral columns of the cord above the first thoracic segment on the opposite side. Less satisfactory results are noted when *rhizotomy* (section of the posterior roots) is applied to the first five thoracic roots on the same side as the pain. The arbitrary destruction of the second and adjacent thoracic cervical ganglia (thoracic raminectomy or ganglionectomy) in the hopes of catching most of these

vascular pain fibers as they enter the spinal roots is strongly to favor blind chance or luck rather than scientific reason, for the

*Controlled Ascending Spinal Anesthesia Test.* The patient is placed with the hips slightly above the level of the head. (Fig. 2.) Lumbar

CHART I

Structure Stimulated (Observations by Author)	Area of Reference	Type of Pain
Brain cortex (ascending parietal convolution)	Contralateral. Hands, feet, arms, legs, trunk, etc.	Burning, tingling electrical, pins and needles
Brain cortex—elsewhere	None	None
Middle cerebral artery (at and below Sylvian fissure)	Homolateral side of head—deep in eye. Diffuse, deep hemierania.	Severe ache, diffuse ache, pressure ache
Middle cerebral artery (Branches above Sylvian fissure)	None	Rarely any response
Anterior cerebral artery (region of corpus callosum)	Homolateral and midline forehead deep above and behind eyes.	Severe ache, pressure and throbbing ache
Posterior cerebral artery (near circle and crus)	Homolateral to parietal area. Deep in eyes.	Severe ache, pressure pain.
Internal carotid artery	Homolateral to lower half of head. Deep in eyes	Severe hemierania. Sharp and aching
Middle meningeal artery	Homolateral to temple. Side of forehead and anterior vertex. Deep in eye.	Severe ache radiating from temple
Thalamus (pathologic involvement)	Large contralateral areas	Burning and hyperalgesia. Tingling.
Neck		
Carotid artery (Bifurcation)	Teeth, gums, upper jaw, head	Severe, aching throbbing.
Anterolateral column (cervical cord)	Opposite arm or leg	Sharp shooting burning and tingling.
Posterior spinal roots	Same side and definite dermatome pattern	Sharp, shooting, tingling and burning.
Peripheral nerve	Distinct to peripheral nerve pattern	Tingling, pins and needles, burning.
Subclavian artery	Shoulder and arm	Intense pressure pain, ache, throb.
Iliac artery	Groin and leg	Intense pain, aching, sickening, diffuse throbbing.

proportionate distribution of pain fibers varies greatly in different individuals, and although we know the majority of the vascular pain fibers enter the upper five thoracic roots, the exact root or roots carrying the fibers desired can only be determined accurately by the following clinical test especially devised for this purpose (Fay and Gotten<sup>1</sup>).

and cisternal needles are introduced. The cisternal needle is attached to a burette system containing sterile saline. When the stylette is removed from the lumbar needle, fluid in the spinal canal will seek the level of the fluid in the burette. If the burette is lowered, the fluid level in the spinal canal falls and air is drawn into the spinal canal as the spinal fluid drains into the cisternal area and the burette. The fluids within and without the canal will find

## Fay--Pain Reference

almost a common level if the burette is placed so that the level of the fluid can be adjusted at any point along the spine and hence along the spinal cord. (Fig. 3.)

patterns are extinguished only with anesthesia of certain roots between the eighth cervical and fifth thoracic segments of the cord.

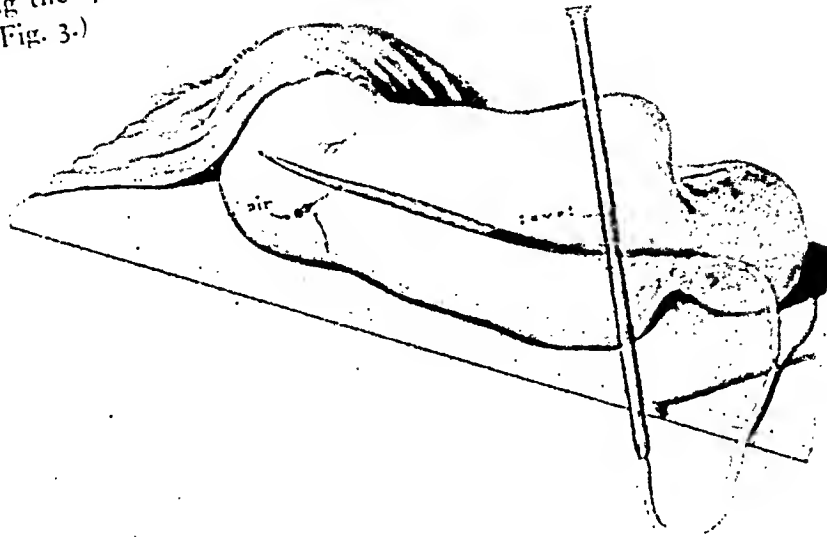


FIG. 3. Diagrammatic representation of an equilization of fluid levels within the spinal canal and the burette. (From Fay, in *Arch. Neurol. & Psychiat.*, 30: 1278, 1933.)

In order to control the exact level of anesthesia, as well as to extend it higher, as appropriate tests and observations are being made, a "light" form of spinal anesthesia (spinocaine) is allowed to run into the lumbar needle just as the column of fluid in the canal starts to fall. As air is drawn into the canal above the spinocaine, the roots and the cord are bathed in anesthetic. Thus, as more and more of the cord and its roots are anesthetized, the level where all pain response ceases can be determined and the exact roots identified by their corresponding skin segments which can be recognized subjectively and objectively.

Appropriate root levels for rhizotomy may be established by this test or the fact that pain is carried by other pathways than the peripheral nerve system. Consequently, unnecessary and futile peripheral measures for relief of pain may be avoided. The test further serves as a differential diagnostic means for distinguishing between the psychalgias and the organic group.

Peripheral nerve and root patterns of pain become extinguished with anesthesia of their respective dermatomes. Vascular

The surgical measures available for relief of pain today meet almost every requirement. Some are more serious than others. From the standpoint of the pain mechanism, they may be listed in a centripetal manner.

(a) *Local Measures.* Surgical relief of constrictions, adhesions, correction of neuromas, removal of painful parts and areas when indicated. (Lo, Fig. 4.)

(b) *Nerve Block.* Injection of 95 per cent alcohol into the sensory nerve trunk supplying the area involved. (I have found it possible to inject even small sensory branches by attaching one pole of the faradic battery to a fine hyponeedle. The response to a small current will indicate the exact location of the nerve.) (P.N. Fig. 4.)

(c) *Paravertebral Block.* This is used in an attempt to produce more lasting effects by destruction of the ganglion cells by 95 per cent alcohol. Some vascular pain fibers can be reached by this means and results are often gratifying. Inaccuracies as to the exact ganglia desired as well as technical

errors make the method unreliable and variable as to results.

(d) *Paravertebral Ganglionectomy or Raminectomy.* This procedure concerns

avulsing or dissecting out the desired sympathetic ganglion, as well as section of the rami communicans. Although used primarily for its effect on vasomotor prob-

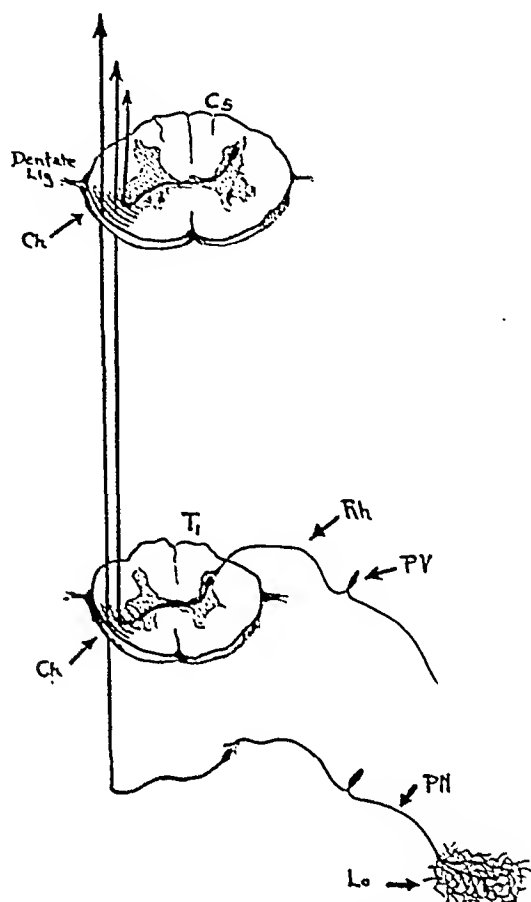


FIG. 4. Diagrammatic representation of the position of the pain fibers in the spinal cord and their relationship to the peripheral pain mechanism. The various levels for surgical control of pain are indicated.

*Cb* (Chordotomy), section of the anterolateral column for relief of pain; superficial fibers from the lower extremity of the opposite side. Chordotomy at  $C_5$  required in order to include vascular pain fibers from head, trunk and extremities. Chordotomy at  $T_1$  insures vascular and peripheral pain fibers from the lower extremity and pelvic viscera.

*Rb*, posterior root carrying pain sectioned or destroyed in rhizotomy. One or more roots may be destroyed depending upon extent of symptoms.

*Pr*, perivertebral injection with 95 per cent alcohol frequently used in an attempt to secure both vascular and peripheral pain fibers. Accuracy of the injection as well as definite ganglia selected will determine the result.

*PN*, peripheral nerve block by alcohol or section.

*Lo*, peripheral pain network controlled by means of local anesthesia.

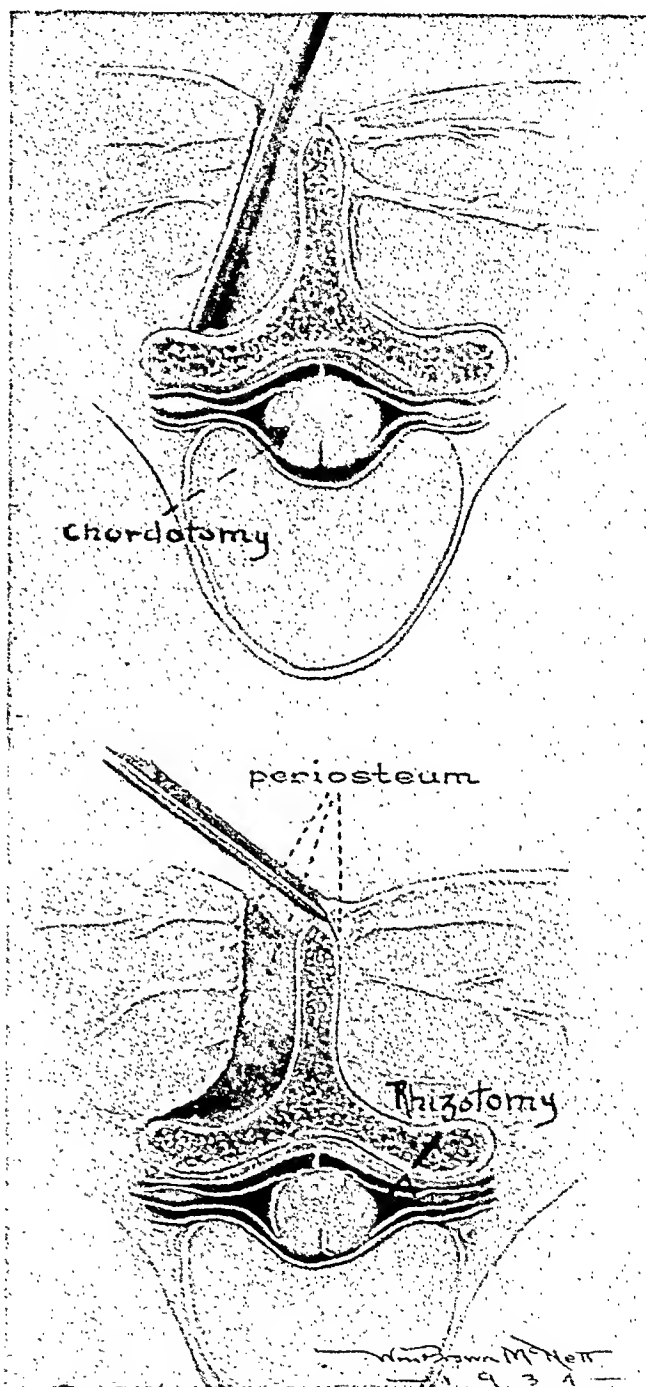


FIG. 5. Subperiosteal exposure of the lamina with preservation of the muscle bed attachments and lateral extension so as to include the base of the lamina and its articular surface. For chordotomy, visualization of the lateral surface of the cord must be obtained in order that accurate section of cord fibers may be secured. A hemilateral laminectomy is often sufficient. For rhizotomy, the dorsal roots must be exposed and laminectomy of two or more segments is required (From Fay, in *Pennsylvania M. J.*, May, 1935.)

## Fay—Pain Reference

lems, relief of pain has been noted and is to be expected where certain vascular pain pathways are involved, especially in the upper thoracic region, as shown in Figure 1.

This procedure if properly performed and properly placed will relieve all pain on the opposite side. Bilateral chordotomy has been possible in some cases without other

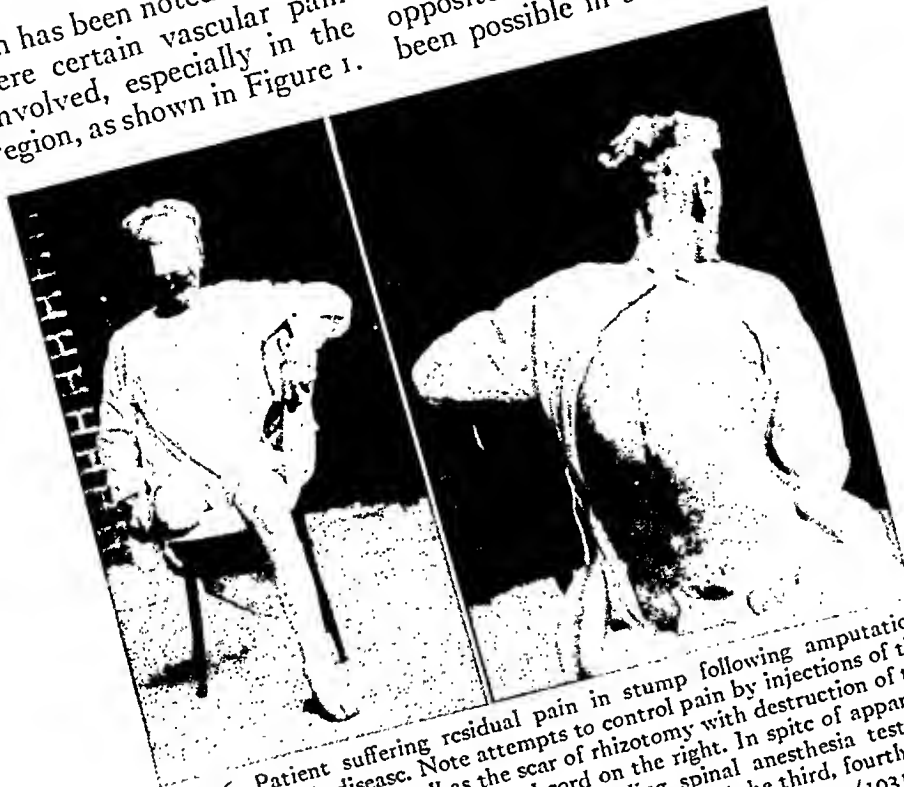


FIG. 6. Patient suffering residual pain in stump following amputation for Buerger's disease. Note attempts to control pain by injections of the sciatic, its roots, as well as the scar of rhizotomy with destruction of the sensory roots of the lumbosacral cord on the right. In spite of apparent total anesthesia, pain persisted. Ascending spinal anesthesia test revealed relief of pain only when anesthesia included the third, fourth and fifth thoracic roots on the right. Observations on this patient (1931) led to the discovery that vascular pain fibers enter high in the cord and chordotomy at  $T_1$  was required to relieve this type of pain.

(e) *Rhizotomy*. This may be classed as a major operative procedure and requires laminectomy with exposure of three or more roots of the spinal cord. The desired posterior sensory roots are carefully identified, crushed and sectioned. (Fig. 4, Rb; Fig. 5.) The patient should be permitted to come out of the anesthetic and identify the pain and its location, when the suspected roots are carefully stimulated. Rhizotomy destroys all other forms of sensation as well as pain. It is therefore not desirable in problems involving the fingers, hands or feet. An anesthetic hand is quite useless.

(f) *Chordotomy* or section of the anterolateral columns of the spinal cord destroys only the sensation of pain. If the cut is made slightly greater in extent, perception of extremes of heat and cold is also lost.

disability. The exact position of the anterolateral columns must be known for the various levels at which chordotomy is to be done. The relationship of these cord pathways to the dentate ligament must be established. (Fig. 4, Cb; Fig. 5.)

Figure 4 (Cb) indicates two levels for chordotomy;  $T_1$  (thoracic 1) is most desirable for pain in the lower half of the body. Peripheral nerve and vascular pain fibers from the legs have all entered and crossed below this level. Chordotomy at  $C_5$  (cervical 5) is necessary to destroy vascular pain fibers from the head, neck and thorax. It will also relieve peripheral nerve pain in the upper extremity as far up as the shoulder cap. Chordotomy at other levels may be indicated, provided the ascending spinal anesthesia test assures relief of symptoms.

The popular level of  $T_5$  for chordotomy, in the past, failed often to relieve problems involving vascular pain of the lower

visceral organs follow certain reflex segmental pain arcs which are familiar and easily recognized.

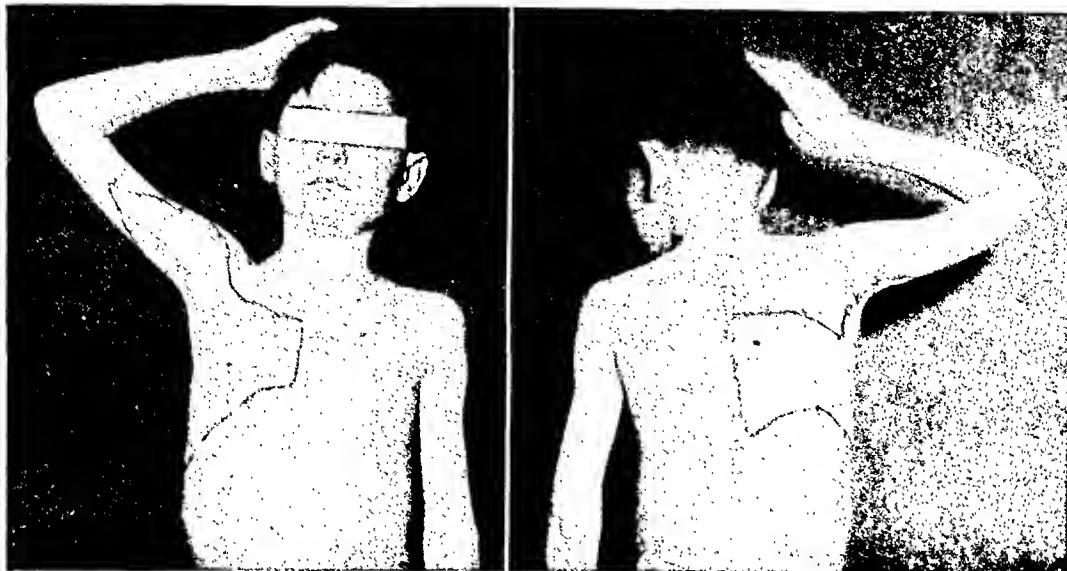


FIG. 7. Case 1. Showing postoperative sear and area of anesthesia following rhizotomy for intense anginal pain referred to the right upper arm and chest. Complete relief of pain with area of anesthesia outlined by skin pencil.

extremities, because these fibers entered the cord along roots  $T_2$ ,  $T_3$ ,  $T_4$  and  $T_5$  above the level of section, and the patient, although showing objective signs of superficial anesthesia in the leg, often still complained of pain, to the dismay and confusion of the neurosurgeon. Spiegel<sup>2</sup> has pointed out intersegmental pathways of pain that may account for certain unrelieved cases. Chordotomy as an operative procedure is the method of choice, as it can be done quickly through a small area and with little attendant shock. The operator must, however, determine the exact level of the cord to be sectioned and the exact area of the cord to be destroyed.

With the recognition that the pain mechanism concerns primarily two great systems, (a) the peripheral nerve pattern and (b) the vascular tree, the need of careful questioning relative to the character of the pain and its distribution will be further apparent.

In the majority of instances, the patient should be able to trace the pain distribution and direction, so that the examiner may be able to detect at once the anatomic characteristics of nerves or vessels. The

Where nerves and vessels are closely associated, as in the axilla and the groin, differential tests must be applied. Here the neurologic examination, as it concerns the pain mechanism, is simple and informative. The ascending spinal anesthesia test can be employed in cases of doubt.

Problems concerned with the peripheral nerves, where trauma or selective involvement gives rise to characteristic sensory patterns and pain reference have been dealt with in detail by Davis and Pollock,<sup>3</sup> Babcock<sup>4</sup> and others. Of more interest and concern, from the standpoint of this paper at least, will be those conditions of pain reference which offer difficulties in recognition, diagnosis and treatment.

Lesions involving the pain pathways of the cord (spinothalamic tract or anterolateral column) which may project their symptoms into the extremities, lesions of the nerve roots within and without the canal, pains of visceral origin (cardiovascular, sacral, pelvic) which find reference into the arms and legs, certain intractable states of pain following amputation of a member—all these require special consideration as to diagnosis and treatment.

## Fay—Pain Reference

If rational measures of relief are to be applied, then an exact knowledge of the pain structures involved and the pathways

individual's attention concentrated upon the act, the experience would be one of extreme suffering and reaction.

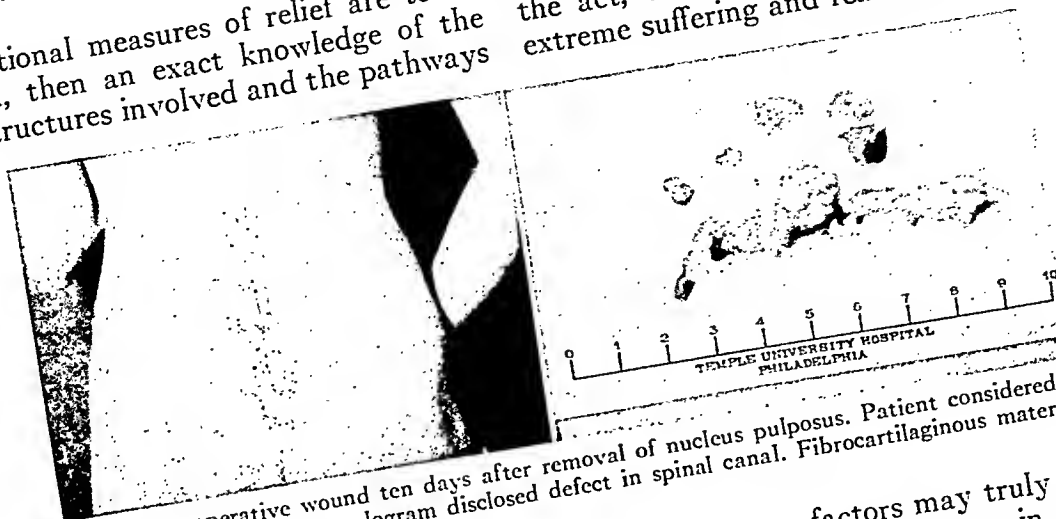


FIG. 8. Postoperative wound ten days after removal of nucleus pulposus. Patient considered a case of sciatica until myelogram disclosed defect in spinal canal. Fibrocartilaginous material removed.

by which these impulses reach the brain must be established.

The following physio-anatomic facts briefly enumerated will aid in clarifying the problem.

In order that an individual feel and appreciate pain, the thalamus must be intact. Central irritation at this level gives rise to widespread contralateral *hyperalgesia* and often burning pain; lightly touching the skin surface may be highly painful and although projection may occur into an arm or leg, it is usual to find tendencies to include body areas as well, and hemilateral syndromes may be present.

Above the thalamic level, painful sensations are integrated, evaluated and localized by the cerebral cortex. In order that pain may be described, localized and appreciated by the individual, consciousness must be present, and, furthermore, there must be attention or concentration of the patient upon the painful sensations. It is well known that painful processes exist, but may be ignored or actually not appreciated, if attention is or can be diverted. The child engrossed in play may receive a painful cut or bruise and remain "unconscious" of this fact until bleeding or some other incident attracts attention to the area involved, pain then is fully appreciated. If the same amount of injury were to be deliberately inflicted with the

Thus, many factors may truly alter the circumstances surrounding pain, as many patients may "concentrate on" or "ignore" their pain processes. Too frequently even well trained examiners hastily conclude that certain patients belong in the "functional group" or term their complaints due to "psychalgia" when no readily apparent reason for the pain can be disclosed. It is true that certain races and individuals bear pain more stoically than others. This is readily demonstrable during certain steps in an exploratory craniotomy. I frequently find it necessary to resort to "local" and "vocal" anesthesia where a general anesthetic would be undesirable or contraindicated. Especially is this so when dealing with cerebellar tumors in children.

In the Nordic, the Angle and the Saxon types, attention is easily diverted and painful steps accomplished without much complaint by means of "vocal" anesthesia or forced conversation with the patient during operation. In the Dravidian and Semitic types, the same procedures and methods are associated with definitely greater responses and suffering.

The cases here presented all illustrate problems of pain, in which, for one reason or another, there was a failure to find relief from the usual sources. These patients had been discarded into the "neurotic" or



"functional" group, with little hope of salvage. The fact that these pain problems proved to be demonstrably real and curable

This case serves to illustrate the root level ( $T_2$ ,  $T_3$  and  $T_4$ ) where the major portion of vascular pain fibers from the heart



FIG. 9. Myelographic study of the lumbosacral region. Note normal cigar-shaped canal when filled with air (outlined by dots). Characteristic defect caused by a protrusion of the nucleus pulposus with compression of the fifth lumbar and first sacral roots, simulating sciatica, indicated by arrows.

only serves to warn us against attempting to evaluate the patient's suffering until we have an intimate understanding of his background, personality, meaning of symptoms and the pain pathways which carry the impulses to a stoical or self-conscious brain.

#### CASE REPORTS

CASE 1. L. C., age 13 was referred by the Medical Department November 30, 1937.

*Diagnosis:* Aortic regurgitation and stenosis with severe anginal attacks. Pain radiating across right breast and inner side of the arm to the elbow.

*Operation:* Exploratory laminectomy with rhizotomy done December 6. Section of the second, third and fourth posterior roots on the right.

*Result:* Patient made a prompt postoperative recovery. Entirely free from pain for first time since onset of attacks two years before. Anesthesia, inner arm and upper chest. (Fig. 7.)

and aorta enter the cord. Section of these roots brought about complete relief of pain.

CASE 11. H. S., age 57, was referred by Dr. W. A. Steel and admitted August 18, 1935.

*Diagnosis:* Painful stump ("amputation neuroma") following removal of the right leg for Buerger's disease.

The patient suffered burning, constant pain in the stump with some projection to absent toes. The stump was very sensitive. The patient cried and moaned continuously, and required narcotics. He had had *section of the sciatic nerve, section of the anterior crural nerve, injection of the lumbosacral roots, paravertebral injections*. Pain persisted in the stump although the skin surface was anesthetic.

The ascending spinal anesthesia test showed *complete anesthesia to below the umbilicus ( $T_9$ )*, but the stump remained painful and deep pressure caused intense pain. *Complete anesthesia to below the nipple line ( $T_6$ )* left the pain persistent in the stump, but rendered manipulation less painful. *Complete anesthesia to the*

## Fay—Pain Reference

axilla ( $T_3$ ) made the patient entirely free of pain. No pain occurred on deep pressure or manipulation of the stump. Diagnosis was

Diagnosis: Sciatic neuritis, left.  
For past four years, the patient had had a dull, aching pain in the left lower extremity.

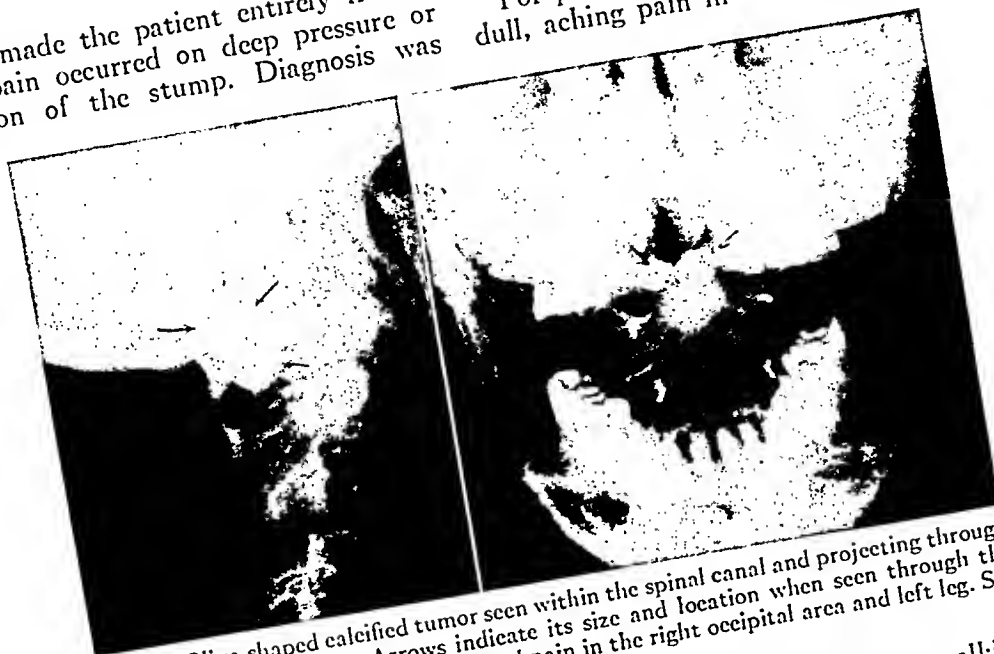


FIG. 10. Olive-shaped calcified tumor seen within the spinal canal and projecting through the foramen magnum. Arrows indicate its size and location when seen through the mouth. Turning of the head produced pain in the right occipital area and left leg. See Case IV. (X-rays by W. E. Chamberlain.)

therefore vascular pain, fibers entering  $T_3$ ,  $T_4$  and  $T_5$ . Recommendation: Chordotomy at  $T_1$ .

Operation: Exploratory laminectomy for chordotomy was done August 21. Exposure of cord below the seventh cervical and first thoracic lamina was followed by section of the anterolateral column on the left side.

Result: Patient made a prompt postoperative recovery. Relief of pain with correction of narcotic habit followed. He has been pain-free three years and five months—to the present time.

This case serves to illustrate the value of the ascending spinal anesthesia test in a patient who was thought to be a case of psychalgia, because apparently all the sensory nerves to the leg and stump had been destroyed and the skin was anesthetic, but still he complained of pain. Entry of vascular pain fibers from the lower extremities occurs chiefly into roots  $T_3$ ,  $T_4$  and  $T_5$ . The cause of pain in this instance was probably further pathology or irritation of the arterial tree above the level of amputation.

CASE III: S. G., age 22, was referred by Dr. John Royal Moore and admitted April 26, 1937.

The pain was worse when walking, standing, coughing or sneezing. An Ober fasciotomy and transection of the piriformis, left, had been done in January, 1937 with only slight relief.

Myelogram: "There is a deformity along the left side of the canal, at the level of the lamina of the fifth vertebra. This deformity consists of a rounded prominence which protrudes into the subarachnoid space." (Fig. 9.)

Operation: Exploratory laminectomy of the lower lumbar region was done May 13. A tumor about the size of an almond, situated at the left side beneath the fifth lumbar lamina and anterior to the root of exit, which proved to be nucleus pulposus, was found. (Fig. 8.)

Result: Patient made an uneventful postoperative recovery and was free from pain upon discharge. (Fig. 8.)

This case serves to emphasize the importance of visualizing the spinal canal by means of oxygen or air when root pathology is suspected. The defect was readily seen (Fig. 9) and the protruding disc material removed (Fig. 8) at operation.

In spite of the frequency with which the diagnosis of sciatica is made, in my experience true sciatica is extremely rare and "double sciatica" almost invariably denotes a cord lesion. What is so frequently

called "sciatica" is either root or peripheral compression. This diagnosis always calls for careful and complete neurologic studies.

CASE IV. Mrs. L. B., age 78, was admitted December 20, 1935 with a diagnosis of high cervical pain.

The patient had been to thirty-three doctors, including several specialists. She complained of pain in the back of the head, on the right side, and burning, shooting pain in the left leg. One of the leading neurologists had made the diagnosis of "occipital neuralgia" on the right side and "Buerger's disease" of the left leg.

The patient had the pains simultaneously and usually when she turned her head to the right and upward. There was slight decrease in pain and temperature perception of the left leg and distinct impairment of sensation over the occipital area and angle of the jaw, on the right ( $C_2$  and  $C_3$ ). Aside from this, the patient had no other neurological findings.

A lesion involving the right anterolateral column was predicted at the level of the atlas. Special x-ray studies were requested and the films (Fig. 10) were quite diagnostic. The pain reference in this case to the opposite lower extremity was characteristic of spinal cord irritation.

*Result:* Exploratory laminectomy, under local anesthesia was done on December 30. A calcified meningioma, the size of an olive, was removed. Postoperative recovery was prompt the patient has been pain-free and well for the past three years; she travels extensively and carries on her lecture work at 81.

This case serves to illustrate a central form of pain projected into an extremity and not to be confused with local "cramps" or disease of an extremity. The sharp root pain to the occiput was intense enough to

be considered a neuralgia, and in a traumatic sense it proved to be of the compression type.

#### SUMMARY

Pain reference into the extremities may be of nerve, root, or cord origin. When a distinct peripheral nerve pattern cannot be established, the clinician must analyze the character and location of the pain to determine whether it is anatomic to the nervous structures or whether it follows the vascular pattern. Appropriate measures for the relief of pain will depend upon the structures involved.

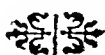
The ascending spinal anesthesia test and careful neurologic studies may be required before determining what surgical method to use.

A patient claiming to suffer pain should not be classed as a "functional" or "psychalgic" type merely because the mechanism of pain is not at once obvious.

Satisfactory results from surgical measures, for relief of pain, can only be expected when the pain mechanism and its pathways are clearly understood and interruption of the proper fibers at the proper levels carefully undertaken.

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# NERVE GRAFTS

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It is often questioned whether or not free nerve grafts are of practical value and on this there is considerable difference of opinion ranging from the conviction that they are useless to the belief that they are successful. In this paper an attempt is made to contribute data from both our experimental and our clinical experience with autogenous nerve grafts.



FIG. 1. Low power photomicrograph of a fresh autogenous nerve graft in the sciatic nerve of a cat four weeks after the operation. To the left is the proximal nerve, to the right the distal nerve. Between the two bits of sutures lies the graft. The new axons stain black. The gradually decreasing number as one approaches the distal end is apparent.

of them curl up in the scar cap, forming a bulbous neuroma, but a few grow through into the surrounding tissue. If the gap between the nerve ends is over 2 cm. very few fibers ever find the distal nerve end.

Meanwhile the distal portion of the nerve swells from the proliferation of the cells of the sheath of Swan. The myelin disappears, the axones fragment and absorb, and protoplasmic strands known as bands of Bungner form through the length of the nerve. These later act as guides for the axones that grow down from the proximal portion of the nerve. This Wallerian degeneration occurs in two weeks. The cut end becomes capped over by a growth of nerve connective tissue as a small glioma in contrast to the large neuroma terminating the proximal fragment.

Also, in a series of thirty-two autogenous nerve grafts done by Sterling Bunnell in twenty-one patients, the results are listed.

*Review of Nerve Repair.* When a nerve is severed both ends undergo a change. In the proximal portion connective tissue soon caps over the end, forming a barrier to the downward growth of axones. The nerve trunk swells above the severance as each axone splits into many fibrils each of which grows downwards seeking the distal nerve

Nerve ends, when repaired by suture, should first be trimmed back, not timidly so that on the cut surface one sees only a mixture of connective tissue and axone bundles, but boldly until only clear cut

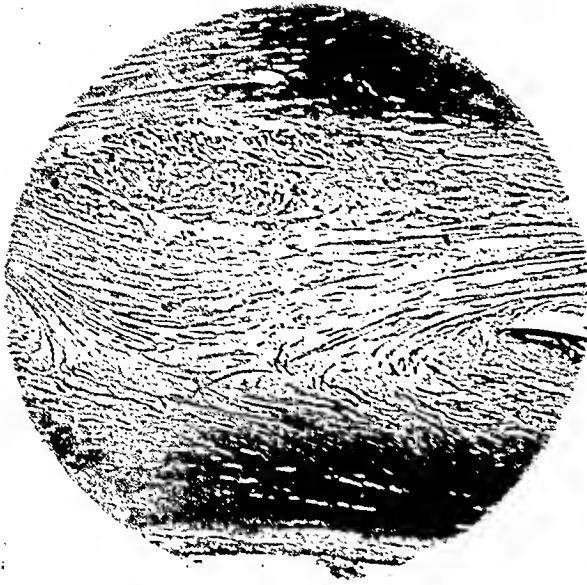


FIG. 2. A higher magnification of Figure 1 showing the proximal suture line. A bit of suture appears at 3 o'clock.

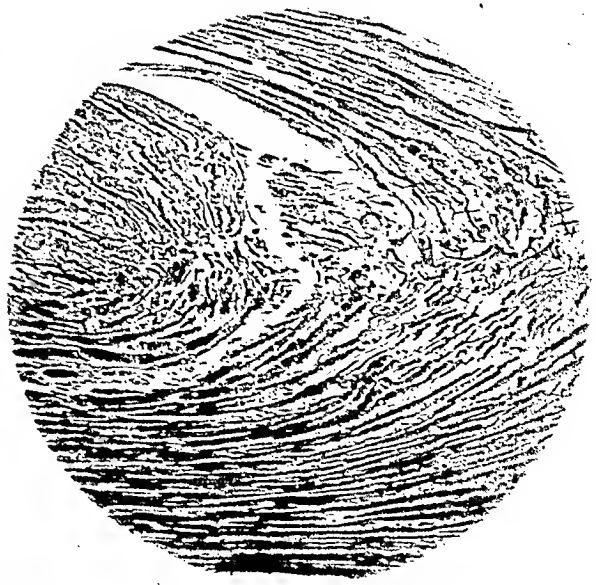


FIG. 3. A section of the proximal suture line of a fresh autogenous graft in the sciatic nerve of a cat six weeks after the operation. At the lower edge are seen the coarse fibers of the proximal nerve; nearer the center, the fibers have become turned back in their course and at the left center some have completely reversed direction. The many spiral tubes called Perroneito apparati are an indication of obstructed growth, in this case due to folding back of nerve tracts; an example of poor approximation.

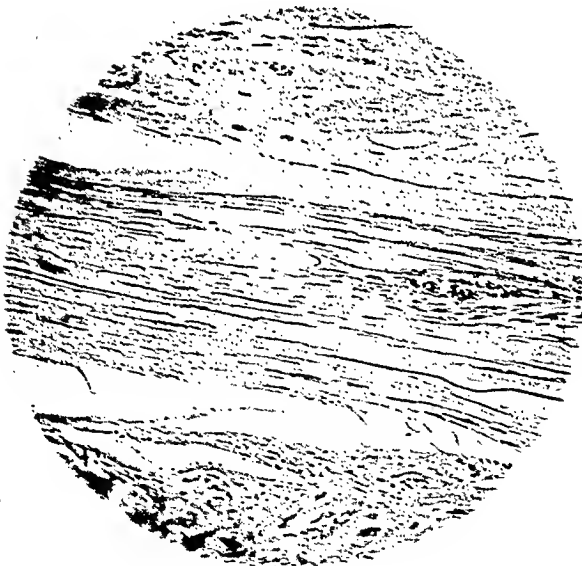


FIG. 4. A section through the mid-portion of a degenerated nerve graft in the sciatic of a cat four weeks after operation. The proximal nerve is to the left. Note that the central core has fewer fibers and that it still contains necrotic products because the graft has not yet developed a good blood supply in the central portion. This explains the failure of grafts of large diameter.

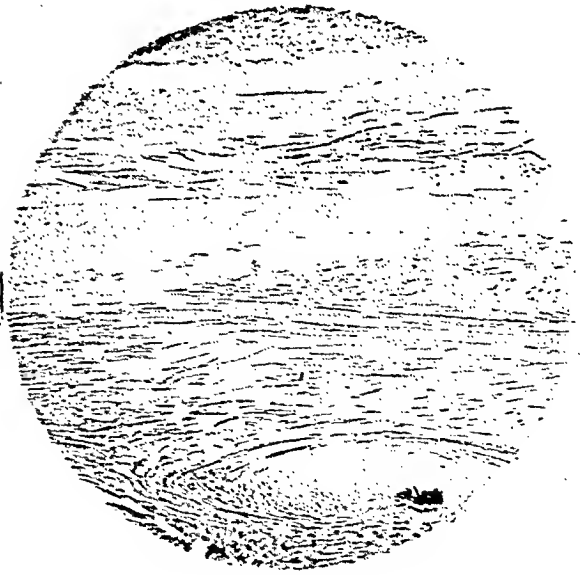


FIG. 5. A section of the distal suture line of a degenerated nerve graft in the sciatic of a cat four weeks after operation, showing nerve fibers crossing the scar joining the nerve graft to the peripheral nerve. A bit of suture at 5 o'clock marks the level of the anastomosis.

axone bundles definitely present. The suturing by the finest blood vessel silk or Deknatel A is through the sheath only and bands of Bungner at the rate of from 1 to 1.5 mm. a day. At first they are nonmyelinated and as they grow down give tingling

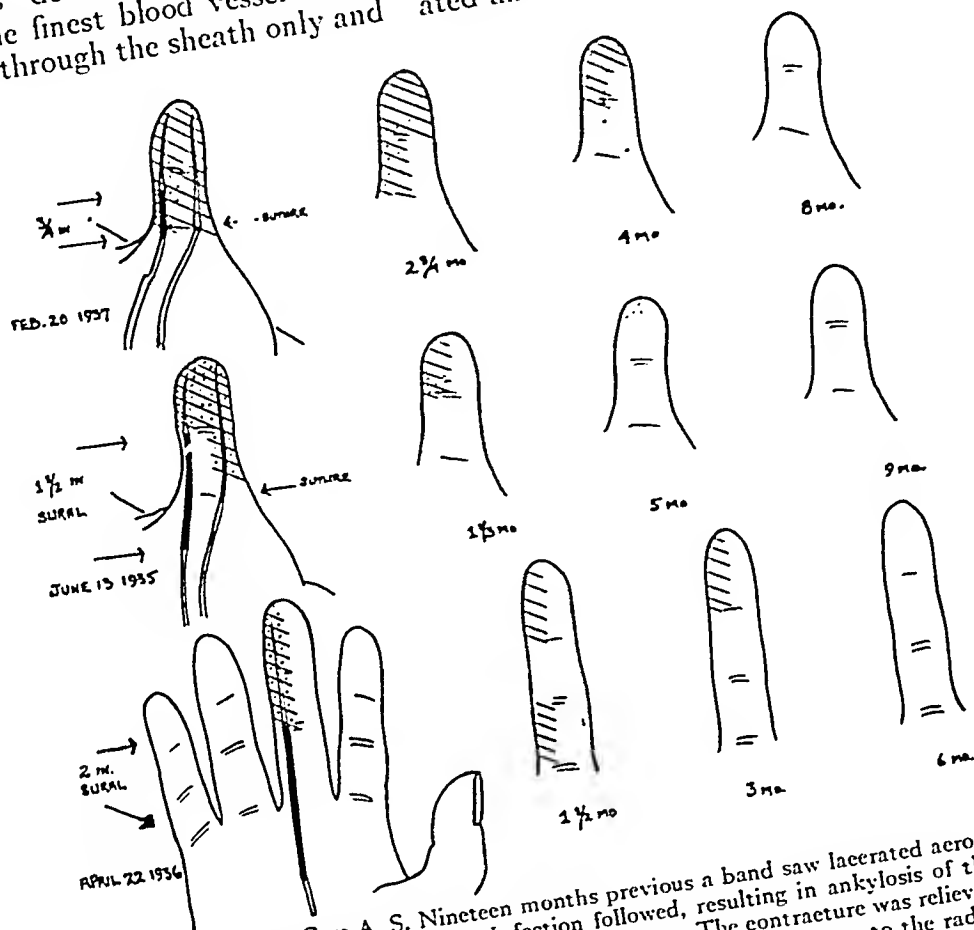


FIG. 6. Upper Row. Case A. S. Nineteen months previous a band saw lacerated across the proximal crease of the thumb. Infection followed, resulting in ankylosis of the proximal joint and loss of the flexor tendon and nerves. The contracture was relieved by zigzagging the scar in the web and repairing the nerves. The nerve to the radial side was sutured while that to the ulnar side was repaired by a free graft taken from the same nerve trunk higher up. Sensation returned to the pulp in eight months.

Middle Row. Case R. B. Six months before a broken bottle had lacerated the right thumb severing both volar nerves and the flexor tendon. The resulting flexion contracture was relieved by plastic swinging of skin flaps. The nerve to the ulnar side was sutured at the proximal crease and a  $1\frac{1}{2}$  inch gap in the nerve to the radial side was closed by a free graft from the sural nerve of the right leg. Sensation returned on the radial side in one and one-third months and on the ulnar side in nine months.

Lower Row. Case J. D. Five and one-half months after an infection of the long finger had destroyed the nerve to the ulnar side of the finger over a distance of 2 inches, the nerve was united by a free graft from the sural nerve. Sensation returned in six months.

should maintain the nerve ends squarely and exactly together with the opposite axone bundles in contact with each other. There should be no gap in the sheath allowing axones to escape and become lost and no gaps between the nerve ends for accumulation of cicatrix which acts as a barrier. Axones will then grow down the

on tapping which later stops as they become myelinated.

The degree of regeneration is in direct proportion to the accuracy of the union. It should be kept in mind in judging from the literature the value of nerve grafts that many useless illogical methods of nerve joinings have been in common use which

could not yield good results. Thus nerve junctures have been made by end-to-side implantation, by turning down nerve

where it will do most harm. Smearing with vaseline provokes a very bad tissue reaction. Inaccurate suturing and leaving a

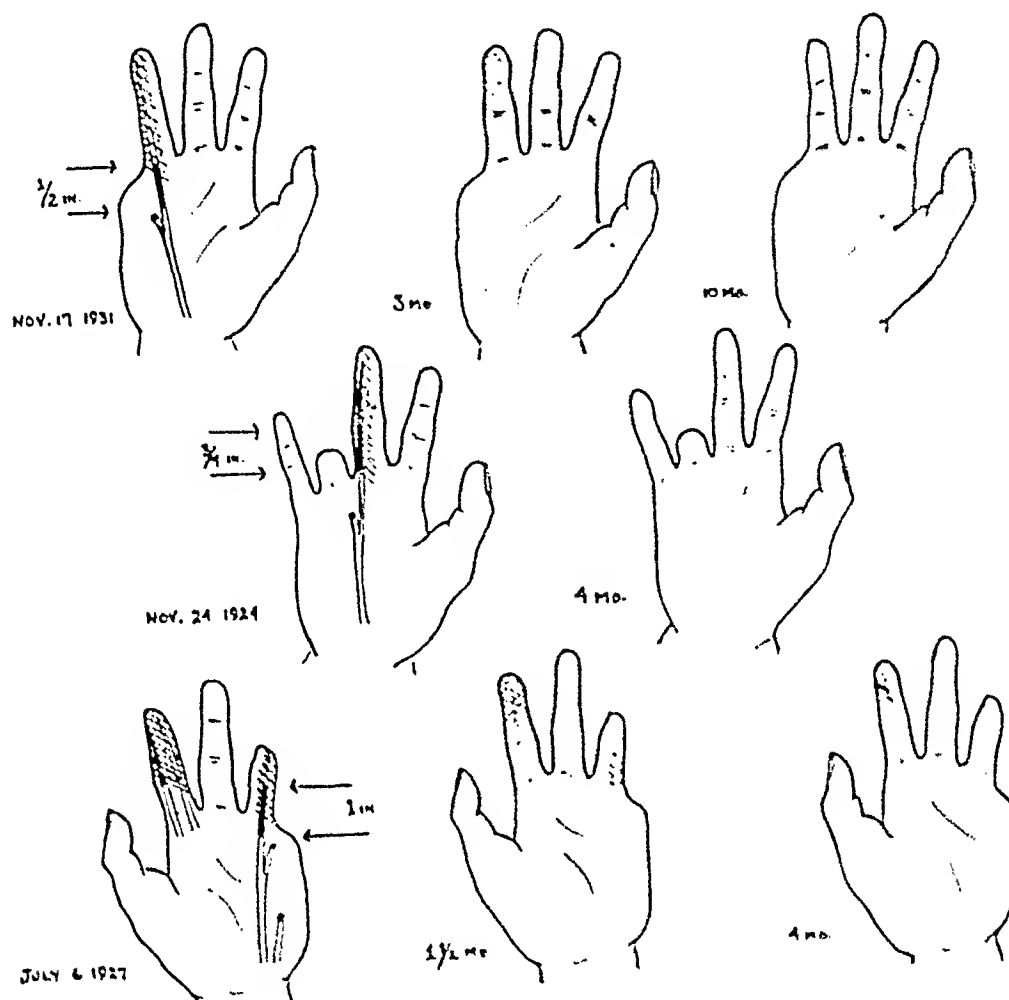


FIG. 7. Upper Row, Case O. E. Eight months after an aeroplane propellor half severed his right hand, a  $\frac{1}{2}$  inch gap in the volar nerve to the ulnar side of the ring finger was closed by a free nerve graft from an adjoining stump of the little finger. Sensation was complete in ten months.

Middle Row, Case H. D. N. Sixty-nine days after a steam shovel had amputated the ring finger and removed a segment of the volar nerve from the adjoining side of the long finger, the  $\frac{3}{4}$  inch gap in the nerve was bridged by a free graft from the radial volar nerve of the amputated finger. Anesthesia to cotton touch and pin prick left the long finger in four months.

Lower Row, Case D. E. Six months after a circular saw lacerated the hand and after a severe subsequent infection, the nerves to the index finger were sutured at the level of the middle joint and an inch gap in the nerve to the ulnar side of the ring finger stump was filled by a free graft taken from the volar nerve to the little finger stump. Sensation was almost complete in four months.

flaps, by sutures at a distance with catgut strands between or a segment of blood vessel, none of which make an end-to-end union of the axone bundles. Also nerve junctures have been wrapped in cargile membrane or other foreign body or placed inside of a segment of blood vessel which effectively block blood supply from surroundings and add excess of scar tissue

nerve suture in a bed of scar tissue instead of displacing it into normal soft tissue will result in strangling cicatrix at the juncture. Therefore, the technique of suture should be weighed in evaluating the results from nerve grafting.

**Overcoming Gaps in Nerves.** Quite a long gap in a nerve can be overcome and the ends of the nerve brought together for



## Bunnell, Boyes—Nerve Grafts

direct suture if we use all the means at our command. In most nerves much length can be gained by freeing them in various places

be flexed if necessary from the trunk to the end of the limb. After a month when the nerve ends have united, the limb is gradu-

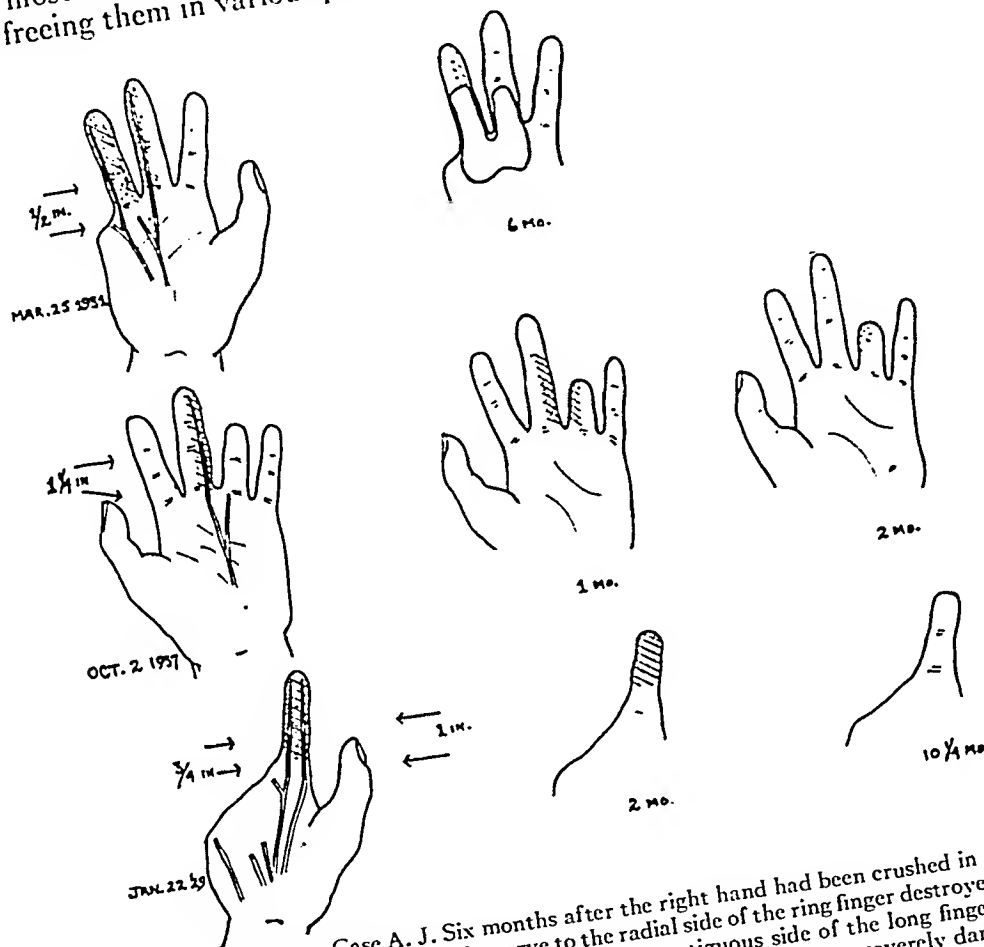


FIG. 8. Upper Row. Case A. J. Six months after the right hand had been crushed in a fly wheel, exploration showed the nerve to the radial side of the ring finger destroyed beyond repair and a  $\frac{1}{2}$  inch gap in that to the contiguous side of the long finger. A free nerve graft was taken from the proximal portion of the more severely damaged nerve to the ring finger, and the whole area was covered by a previously prepared tubular pedicle from the abdomen. Six months later sensation was present over the complete area of the long finger.

Middle Row. Case H. S. Three and one-half months after a saw lacerated the left hand, severing the nerve on the ulnar side of the long finger and amputating the tip of the ring finger, the stump of the ring finger was revised and a  $1\frac{1}{4}$  inch gap in the nerve to the long finger was filled by a free graft from a nerve to the ring finger stump. Sensation returned in two months.

Lower Row. Case E. M. D. Five months after a buzz saw cut across the hand obliquely from the base of the fifth metacarpal to the side of the index finger, the cicatricial index finger was amputated through the middle joint and  $\frac{3}{4}$  inch and 1 inch gaps in its two volar nerves were repaired by free grafts from the adjoining volar nerves in the palm. Sensation was complete in the stump of the index finger in eleven months.

from the surrounding tissues and gently drawing upon them when the joints are flexed. Care must be used not to overpull a nerve or to pull off motor branches as it passes between the muscles. All joints may

ally extended over several weeks so the nerve will have time to grow to its full length again. In some nerves as the ulnar, radial and facial, length can be gained by transposition.

If after an attempt to approximate nerve ends by the above methods, they still will not reach each other, they should

transfer or it may be that a muscle transfer is possible to relieve disability.

Failure of these methods leaves free nerve

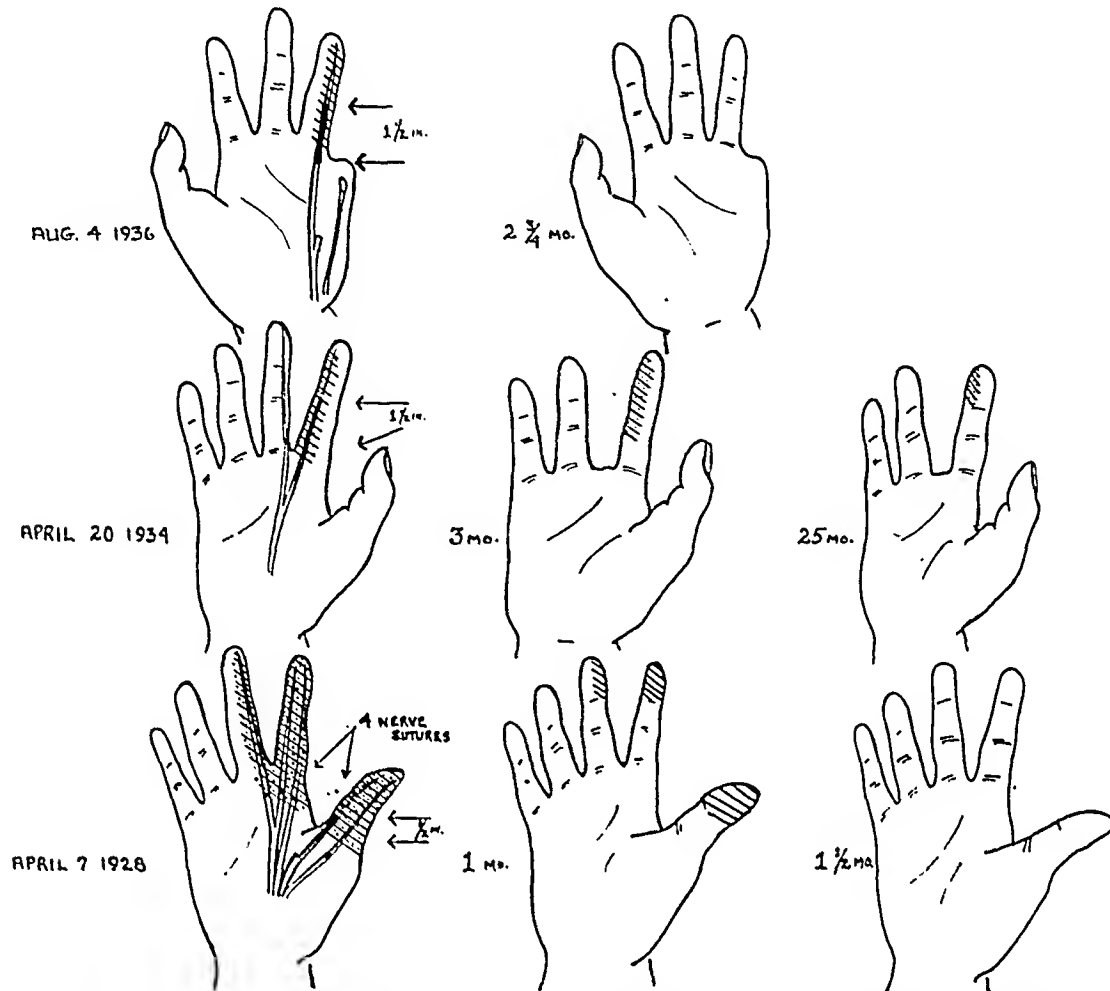


FIG. 9. Upper Row. Case P. L. Three years and two months after a circular saw had amputated the little finger and severed both tendons and one nerve of the ring finger, a  $1\frac{1}{2}$  inch gap in the nerve was bridged by a free graft from the nerve to the stump of the adjacent little finger. Sensation was complete in  $2\frac{3}{4}$  months.

Middle Row. Case L. S. Seven months after severe tenosynovitis destroyed the right long finger and severely crippled the hand and four months after the wounds finally healed, a  $1\frac{1}{2}$  inch gap in the volar nerve to the ulnar side of the index finger was replaced by a free graft from one of the nerves of the amputated long finger. Sensation returned rapidly up to a time two years from operation when a small area of anesthesia was still present on the tip. Atrophy of the skin cleared, however, and sweat glands again functioned in this area.

Lower Row. Case F. LaP. Ten weeks previously the flexor tendons in the right thumb and index finger and five nerves were severed when she fell on a milk bottle. Four nerves were sutured, but that to the ulnar side of the thumb was too short. Therefore, a  $\frac{1}{2}$  inch segment was removed from its proximal end and used as a free graft to join this nerve. Sensation was complete in  $1\frac{1}{2}$  months.

be sutured there to the surrounding tissue. Then, after gradual stretching as above, a second operation should be done. The ends of the nerve may at that time reach each other.

Occasionally a nerve in an amputation stump is available to suture into the distal portion of the severed nerve as a nerve

grafting as the only procedure available. Therefore, its limitations and its values should be known.

*Literature of Nerve Grafts.* Following the first description of the use of a nerve graft by Albert in 1878 a few isolated case reports appeared in the literature, but it was not until the time of the World War

## Bunnell, Boyes—Nerve Grafts

that reports were made of any appreciable number of nerve grafts together with their end results.

these was much less than through fresh autografts.  
Cajal and Forssmann postulated a chemo-

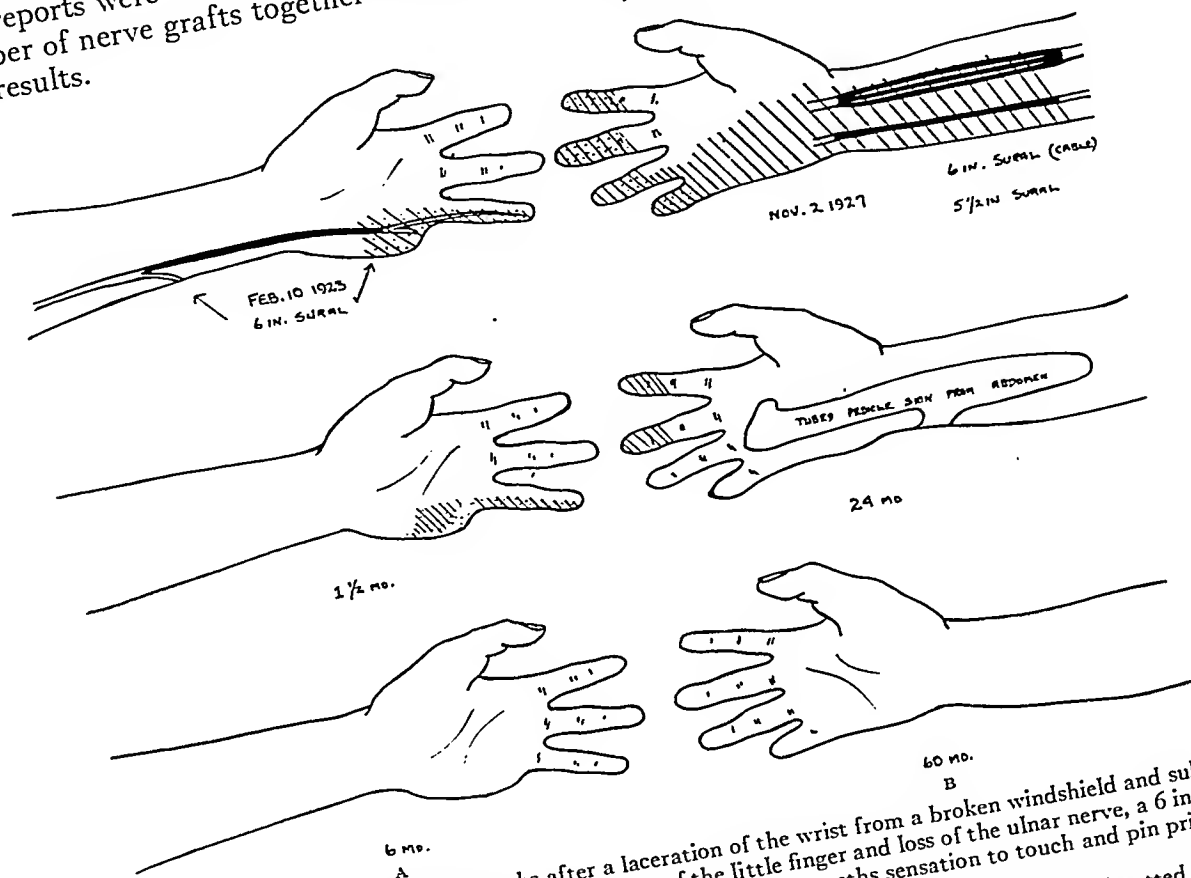


FIG. 10. A, Case J. B. K. Eight months after a laceration of the wrist from a broken windshield and subsequent infection had resulted in an amputation of the little finger and loss of the ulnar nerve, a 6 inch sural graft was placed in the nerve as in the diagram. In five months sensation to touch and pin prick could be felt throughout. The ulnar motor branch had not been sutured.  
B, Case S. T. Eleven months after a blast from a shotgun and subsequent infection had gutted the right forearm of tendons and nerves and after good skin had been supplied by a tubular pedicle from the abdomen, the median nerve was repaired by a three ply 6 inch graft from the sural nerve and the ulnar nerve was united by a single strand  $5\frac{1}{2}$  inches long. Five months later flexor tendons were supplied to all digits, a "pulley" operation for opposition of the thumb was performed and the radial nerve was sutured. Five years after the first operation sensation was present throughout.

Platt's report in 1919 of a series of twenty cases of nerve grafts with complete failure in all gave rise to the note of scepticism among British surgeons which has since pervaded the English literature on the subject. In this series, however, it should be noted that only single nerve strands were used instead of cable grafts and these were enclosed by fascia or vein. Huber concluded that experimentally autografts were successful and, though some regeneration occurred through other types of fresh grafts as well as preserved grafts, the degree of regeneration in

tactic influence in a degenerated nerve which attracted the newly growing fibers from the proximal stump, although Dustin and Huber failed to find basis for this theory.

Balance and Duel used fresh and prepared autografts in repair of the facial nerve and reported their results in a series of articles from 1931 to 1936. In experiments on monkeys they reported that they had obtained regeneration in prepared, that is, previously degenerated nerve grafts in one-half to one-fourth the time necessary for that in fresh autografts. This we do not

believe because of our own experimental findings and those of Bentley and Hill in 1936. The latter reported a series of

action of the distal portion was allowed to progress for two weeks. Then in each a segment from the distal portion was cut

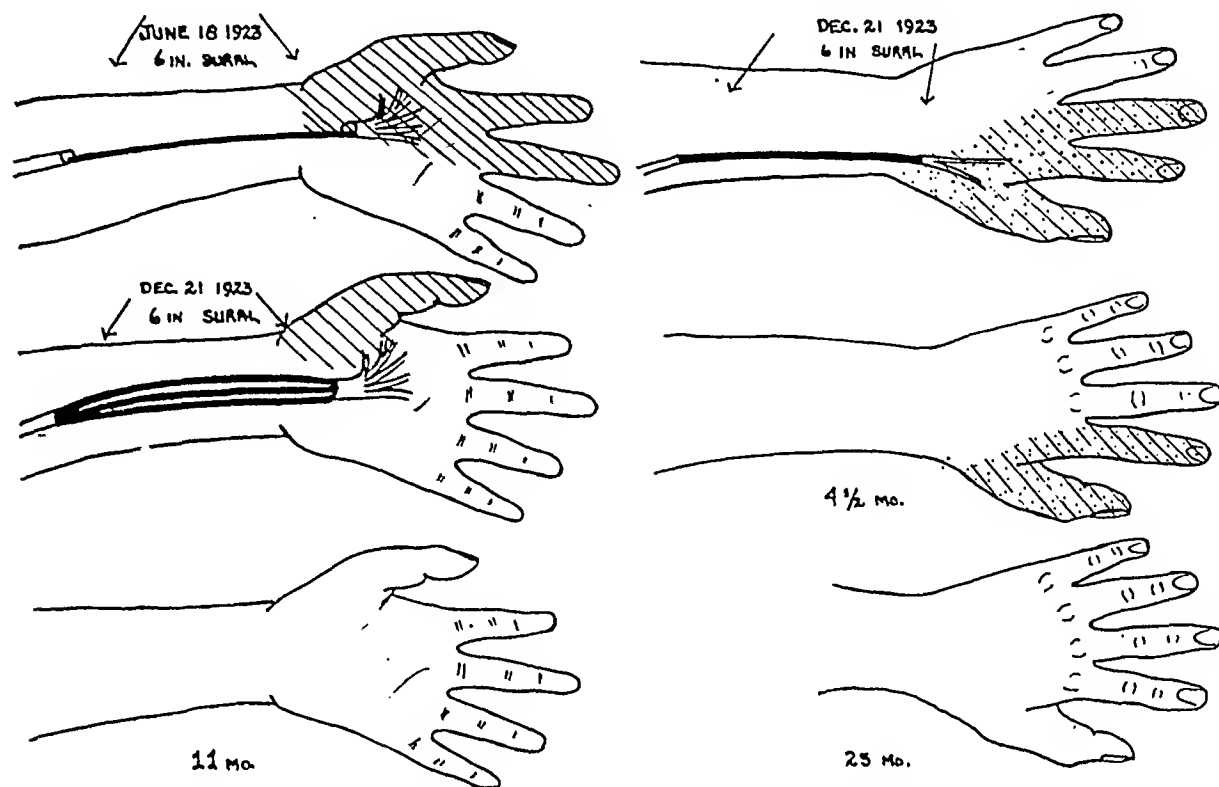


FIG. 11. Case E. B. Four years previously a buzz saw passed two-thirds of the way through the carpus from the radial side, and during the subsequent infection a considerable length of the median and radial nerves sloughed out. On January 18, 1923, a single strand of sural nerve was used to unite the median nerve in the forearm. Six months later some sensation had returned and therefore two other strands were placed in the median nerve and one strand was used to unite the radial nerve. Eleven months later he felt touch and pinprick over the whole arm. In one and one-half years stereognosis had returned.

experiments with the so-called prepared or previously degenerated nerve grafts and concluded that there was no essential difference in the rate of down growth of axones through fresh autogenous grafts or previously degenerated ones.

*Our Experimental Work.* To determine the regeneration following fresh auto nerve grafts compared with that following predegenerated nerve grafts, two series of cats were studied.

In the first series four cats were used. In each a 2 cm. length of sciatic nerve was cut out, reversed end-for-end, and sutured back into place. After intervals of two, four, six and nine weeks respectively, the cats were killed and longitudinal microscopic sections of each nerve and graft were studied.

In the second series of three cats the sciatic nerve was first severed and degener-

out, reversed end-for-end and sutured into continuity with the nerve just as in the first series. The specimens were examined, one in two weeks, another in four weeks and the third in six weeks after operation.

It was found that in two weeks in both the fresh and the degenerated grafts new nerve fibers had already penetrated the full length of the graft and were entering the distal nerve. At four weeks the fibers had increased in number in the grafts and had reached past the second suture line and well into the distal nerve. At six weeks regeneration had progressed further but myelin did not appear until in the specimen obtained after the eighth week.

We concluded that there was no difference in the rate of growth of nerve fibers through fresh and predegenerated auto nerve grafts.

## Bunnell, Boyes—Nerve Grafts

It is interesting to note that the regeneration of nerve fibers was largely in the peripheral zone of the grafts. Here surrounding

which could not be followed postoperatively are not included. The technique used was uniform, accurate perineural or sheath

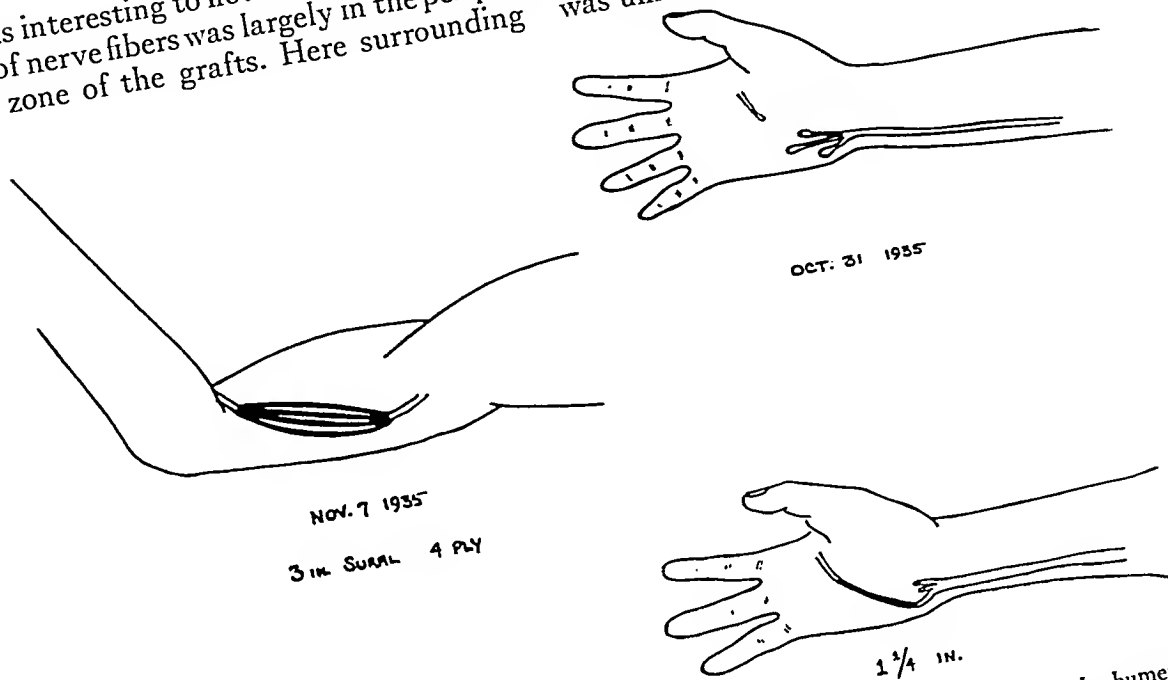


FIG. 12. A, Case F. L. H. Twenty-two and one-half months after a compound fracture of the humerus, received when an oil drum exploded and wrapped its ends around the patient's left arm, and five and one-half months after all osteomyelitis had healed, the musculospiral nerve was bridged by a four ply cable graft 3 inches long from the right sural nerve. Only an inner slip of the triceps had remained innervated. Eighteen months later anesthesia disappeared from the hand and voluntary motion was present in the extensors of the wrist and extensor pollicis longus. Examination three years after operation showed absence of anesthesia and good power to extend fingers and thumb, even with wrist passively held dorsiflexed, but only a little of voluntary dorsiflexion of the wrist. The nerve pathway for dorsiflexion of the wrist was evidently mechanically missed by the down-growing axons, as it is the only nerve branch that did not regenerate and this branch of the radial nerve is usually the first to regain function.

B, Case T. S. H. Four years before, he fell on a glass, severing the ulnar nerve and flexor tendons to the ring and little fingers and opening the wrist joint. Infection followed an attempted primary repair and lasted two months. At operation on October 31, 1935 (performed at meeting of American College of Surgeons) the little finger was amputated including its metacarpal. Its extensor tendon was transferred to the adductor of the thumb, its flexor to the interossei of the ring finger and a  $1\frac{1}{4}$  inch gap in the deep motor branch of the ulnar nerve was closed with a graft from one of the sensory branches of the ulnar. Twenty months later the interossei recovered and their atrophy had disappeared. He could adduct the straight thumb to the same degree as in the opposite hand.

lymph penetrated sufficiently to maintain vitality while the central portion of the graft showed some necrosis. This argues for either small or cable grafts instead of thick ones.

**Clinical Report and Discussion.** In the following series of thirty-two nerve grafts done over a period of fifteen years we have endeavored to keep accurate pre- and post-operative notes and to present a true picture of the results. Two additional cases

suturing with the finest silk and without any intubation by free fat, membrane or foreign body placed around the juncture. The nerves sutured were, wherever possible, merely placed in soft vascular tissue as free from cicatrix as possible.

Grafting was used only where the methods of achieving end-to-end union were exhausted or were inadvisable. Only those nerves were sacrificed for grafts whose function was of less importance than

was the function to be gained. The sural nerve from the center of the calf was usually the graft of choice. The area of result-

amputation distal to it had rendered the nerve functionless. It is neither necessary nor justifiable to sacrifice motor function to

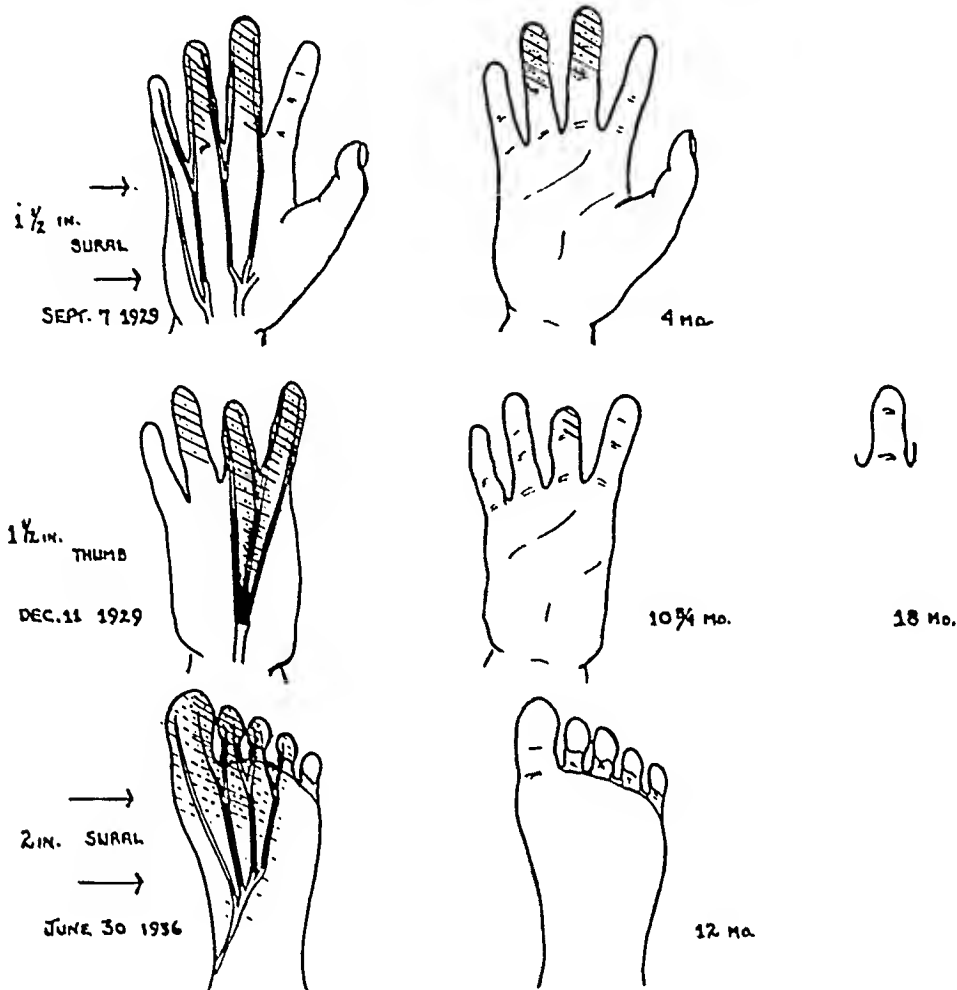


FIG. 13. Upper Row. Case A. T. Four and one-half months previously a saw cut the right palm, severing tendons and nerves. After two operations had been done elsewhere, the  $1\frac{1}{2}$  inch gaps in the volar nerves to the second, third and fourth clefts were closed by free grafts from the left sural nerve. In four months sensation had returned except over the area shaded above, after which he did not return for subsequent examinations.

Middle Row. Case W. A. D. Nine months after the right hand was caught in a kale cutting machine, amputating the thumb and a portion of the long finger and severing all the flexor tendons except the little, and seven months after the infection had subsided, the nerves to the index and long fingers were repaired by three free nerve grafts, one of which was made up of two segments of free nerve ends dissected from the scar in the palm. The remaining two grafts were obtained from the original thumb branches, split from the main trunk of the nerve. Sensation was present throughout eighteen months later.

Lower Row. Case E. W. Ten and three-fourth months previously she stepped on a broken bottle, lacerating the sole of the left foot. At operation a gap of  $1\frac{1}{2}$  inches in the flexor hallucis longus tendon was bridged by a free tendon graft. Each of three branches of the internal plantar nerve had a 2 inch gap in it which was filled by free grafts from the sural nerve of the opposite calf. One year later sensation was present throughout and motion had returned to the great toe.

ing anesthesia from loss of this nerve is small, if any, and patients as yet have not complained. Occasionally a part of some other nerve was available because an

procure a nerve graft. Sensory nerves as grafts have been shown to convey equally well motor or sensory axones when placed in the normal direction or when reversed

end for end. The sural nerve is nearly always available. It is just beneath the mid vein of the calf; in the upper part of the

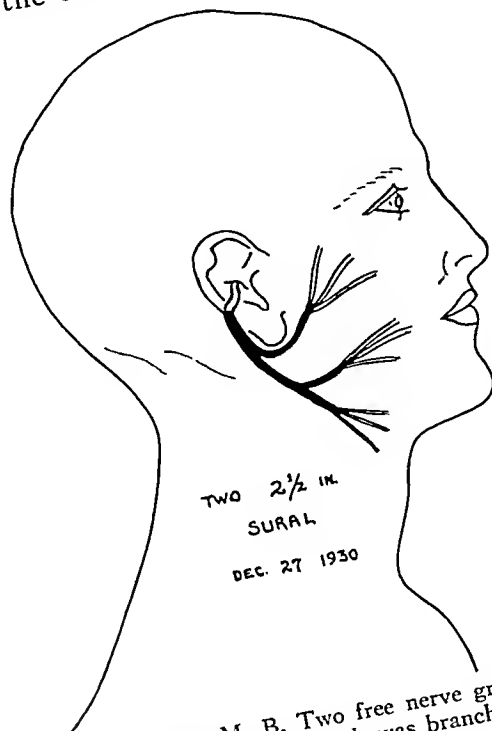


FIG. 14. Case M. B. Two free nerve grafts  $2\frac{1}{2}$  inches long, one of which was branched, were used to repair a facial nerve which had been invaded by a tumor of the parotid gland. Some voluntary motion first appeared in six months, increased in nine months, and in seventeen months symmetry of the face was regained. The tumor later recurred and was excised with the nerve graft en bloc. Sections showed that nerve fibers had grown through the graft into the distal portion of the nerve. This is the first case in which a free nerve graft was used to repair the facial nerve. (Reported in detail in *Arch. Otol.*, 25: 235-259, 1937.)

calf it is under the deep fascia and in the lower part is superficial to it. Of other available sensory nerves the cutaneous branch of the radial, if severed, often leaves a most tender neuroma. The internal cutaneous and sensory branches of the femoral are rather small. The long saphenous, if removed, causes some anesthesia. The sural, therefore, is the nerve of choice. Almost a foot of this nerve is available from each calf, allowing ample material even for a cable graft into a fairly thick nerve. In our series the results are uniformly good in all of the cases that could be traced,

apparently for the following reasons: In this series the nerves grafted were either small in diameter (as the facial nerve or nerves in the hand) or if larger, cable grafts were used made up of multiple small strands of nerve grafts amounting in the total cross section to the size of the nerve itself. These slender stranded nerve grafts were readily kept nourished through and through merely by lying in the surrounding lymph until they acquired a blood supply of their own. In contrast a nerve graft which is large in diameter such as the median or sciatic would not be nourished by surrounding lymph except in a thin peripheral zone and its central portion would undergo necrosis well before its new blood supply would be established. Thus small nerve grafts and cable grafts survive while thick nerve grafts undergo much central necrosis. A nerve graft can hardly be expected to yield as good or as quick a result as a nerve suture because there are in the case of a graft two suture lines each of which forms a cicatricial obstacle through which the axones must penetrate. A nerve suture obviously has only one such line. Even so, however, the speed and degree of regeneration following nerve grafts have compared fairly well with those after nerve suture.

In our series of thirty-two grafts, three were of the cable type and one of the facial nerve was branched into three. The sural nerve was the source of graft in seventeen and other nerves, as in amputation stumps, in thirteen. In two instances a short thin segment from a higher part of the same nerve was split from the nerve and used. The length of grafts used varied from  $1\frac{1}{2}$  to 6 inches.

#### CONCLUSION

1. A series of thirty-two autogenous nerve grafts in the human is reported, with return of some function in all and in many to a considerable degree.
2. Experimentally in cats the axones were demonstrated to grow through the



grafted nerve segment and on down through the nerve.

3. Prepared grafts have no advantage over fresh grafts.

4. A nerve graft to be successful should be small in diameter or made as a cable graft of many small strands so that each strand will be nourished through and through by the circulating surrounding lymph until it has acquired its own blood supply.

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# NON-OPERATIVE PROCEDURES FOR THE RELIEF OF LUMBO-SCIATICA\*

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**R**EFERRED leg pains from lesions of the sacrolumbar spine are everyday problems of the general practitioner. The resulting lumbo-sciatica is too often accepted by the middle aged patient with the resignation accorded false teeth and gray hairs, as the inevitable consequence of mature years. Rest, home remedies and the hot water bag carry the sufferers through their acute attacks. They ignore the constant intermediate chronic ache until eventually they reach the cane supported, limping stage of the semi-invalid. Yet, with proper medical guidance and treatment in the early stages, they could have had many years of comfort before them.

## CAUSE

In a previous article<sup>1</sup> I endeavored to show that faulty posture is the usual predisposing cause of chronic lumbo-sciatica; that this faulty posture results in an exaggeration of the dorsal and lumbar curves of the spinal axis. This spinal tilt in the lumbar region puts an added strain and traction on its related ligaments and attached muscles, and finally causes a perineural irritation of the associated nerve roots with pain referred to their distal branches. Flat foot<sup>2,3</sup> and functional muscular insufficiency<sup>4</sup> are the most frequent causes of faulty posture. (Fig. 1.)

The contributory causes are legion, but may be grouped as referred pain arising from pathology in distant parts, or direct pain arising from pathology in the lumbar spine or its surrounding structures. Summarizing possible causes from the 2,182 cases of authors quoted, one concludes (1)

"that any contributory cause may be important, but that few per se give symptoms without a superimposed acute trauma or the chronic static trauma of poor posture; (2) that causes of chronic lumbo-sciatica whose frequency is exaggerated are toxic foci, constipation, hemorrhoids, prostatitis, female pelvic disease, especially uterine retroversion and retroflexion, anatomic variations in the fifth lumbar vertebra, sacroiliac strain or dislocation, osteoarthritis of the young (the Marie-Strumpell type excepted), and true lumbar muscle fascitis; and (3) that the true cause is usually found in the spine itself, at or about the lumbosacral articulations, since the senile weakening of its ligamentous and muscular supports throws an extra strain on this vulnerable area and hastens the course of local senile fibrotic changes."<sup>1</sup>

## PATHOLOGY

Pain means sensory nerve irritation. When expressed in its terminal branches the irritation is usually about the nerve root. That it is due to a true neuritis is still a much debated question. But the relief following procedures tending to bring more blood into and around the affected nerve; the observation of nerve root changes when exposed by laminectomy;<sup>5,6</sup> and the relief attained by various nerve stretching procedures<sup>1,7,8</sup> indicate that in the majority of chronic cases some degree of peri- and endoneuritis exists.

If "pain is the cry of a suffering nerve for blood," then the pain of *acute sciatica* would follow pelvic nerve root ischemia from perineural pressure of surrounding acutely inflamed structures—periosteum,

\* From the Surgical Service, Temple University Medical School.

ligaments and muscles. A long continued pressure would result in a low grade chronic inflammation with its attending fibrosis. The fibrosis would first appear in the nerve sheath—perineuritis; then gradually invade the nerve trunk—endoneuritis. Contraction of this newly formed fibrous tissue would cause a persistent nerve ischemia and cause the continuous pain of the chronic case. But with the regeneration power characteristic of nerve tissue the neuritis disappears once the primary cause is removed and the secondary nerve changes are treated. Relief attending therapeutic measures and minor surgical procedures tending to bring more blood to the affected nerves would seem to support this hypothesis.

#### SYMPTOMS

The pain of chronic lumbo-sciatica is transmitted down the leg through the lumbosacral and coccygeal plexuses, particularly along the great sciatic and gluteal nerve distributions. In mild cases there is morning back stiffness and muscle fatigue, followed as the day goes on by pain radiating over the sacroiliac joints, buttocks and down the back of the leg. Sciatica may precede but usually follows the backache. The pain is intermittent. It is aggravated by sudden body twists, lifting, exposure to wet and cold or a toxic focus. The majority of cases are in this class and are those apt to be relieved by minor surgical procedures. The severe, long standing case with constant pain, sensory and motor reflex changes and contraction of fascial planes and muscle groups usually requires a major surgical operation for relief.

#### TREATMENT

It is nature's law that senile fibrosis with its accompanying pain first appears in those structures most hardly hit by life's wear and tear. In man, the biped, the erector spinal muscle group is in a state of contraction during all his waking hours. It is but logical that this muscle group and its associated nerves, joints and ligaments

should be the first to exhibit the pain signal of approaching senile fibrotic change. So the cartoonist depicts the old man not as holding his head with both hands but with

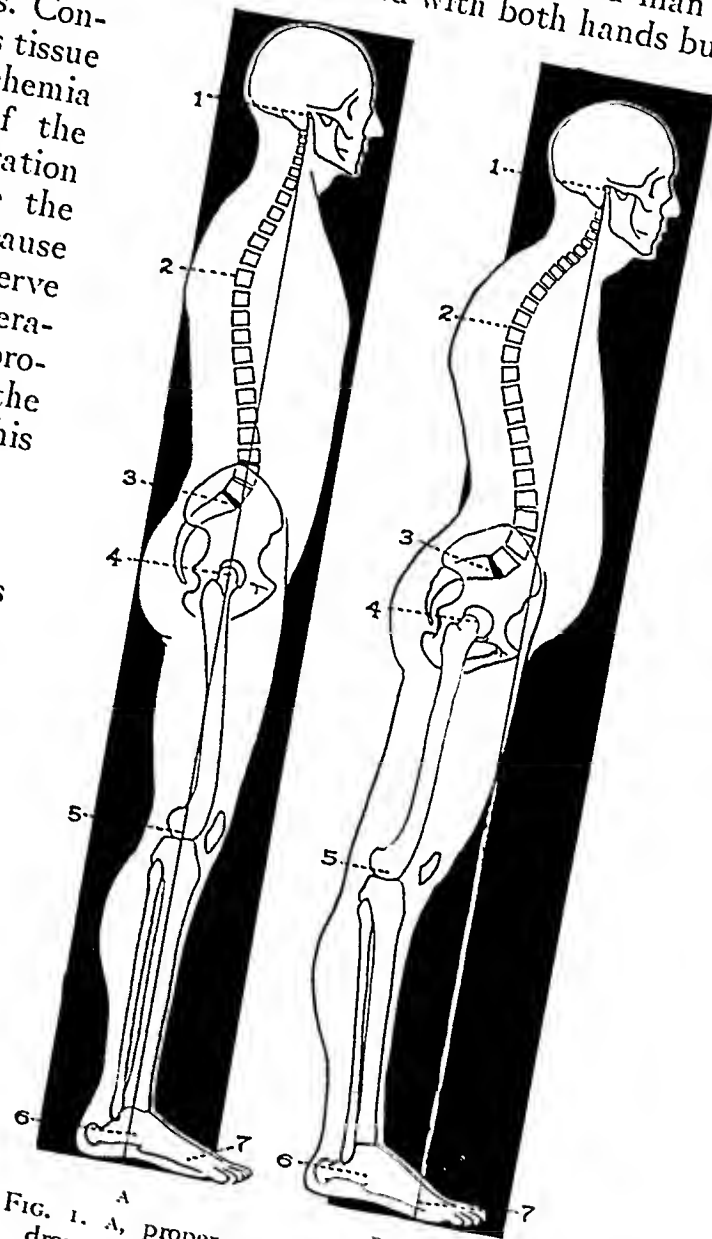


FIG. 1. A, proper posture. A plumb line dropped from the mastoid process (1), passes through the tip of the shoulder, the lumbosacral articulation (3), the hip joint (4), the knee joint (5) and the base of the metatarsals (6). The head is up, shoulders back, dorsal and lumbar curves normal, knees straight and the lumbosacral articulation angle 43 degrees. B, poor posture. The plumb line falls anterior to the lumbosacral junction and strikes the feet about the heads of the metatarsals. General body slump, i.e., head forward, exaggerated dorsal and lumbar curves, protruding abdomen, exaggerated lumbosacral angle, hyperextended knees, feet with a tendency to be flat. (From Steel, in *New England J. Med.* 219: 474, 1938.)

those members supporting a lame back. Correction of predisposing and contributory causes, avoidance of acute trauma and gratifying results that the pessimistic outlook of the past toward chronic lumbago sciatica can be largely changed; the car-

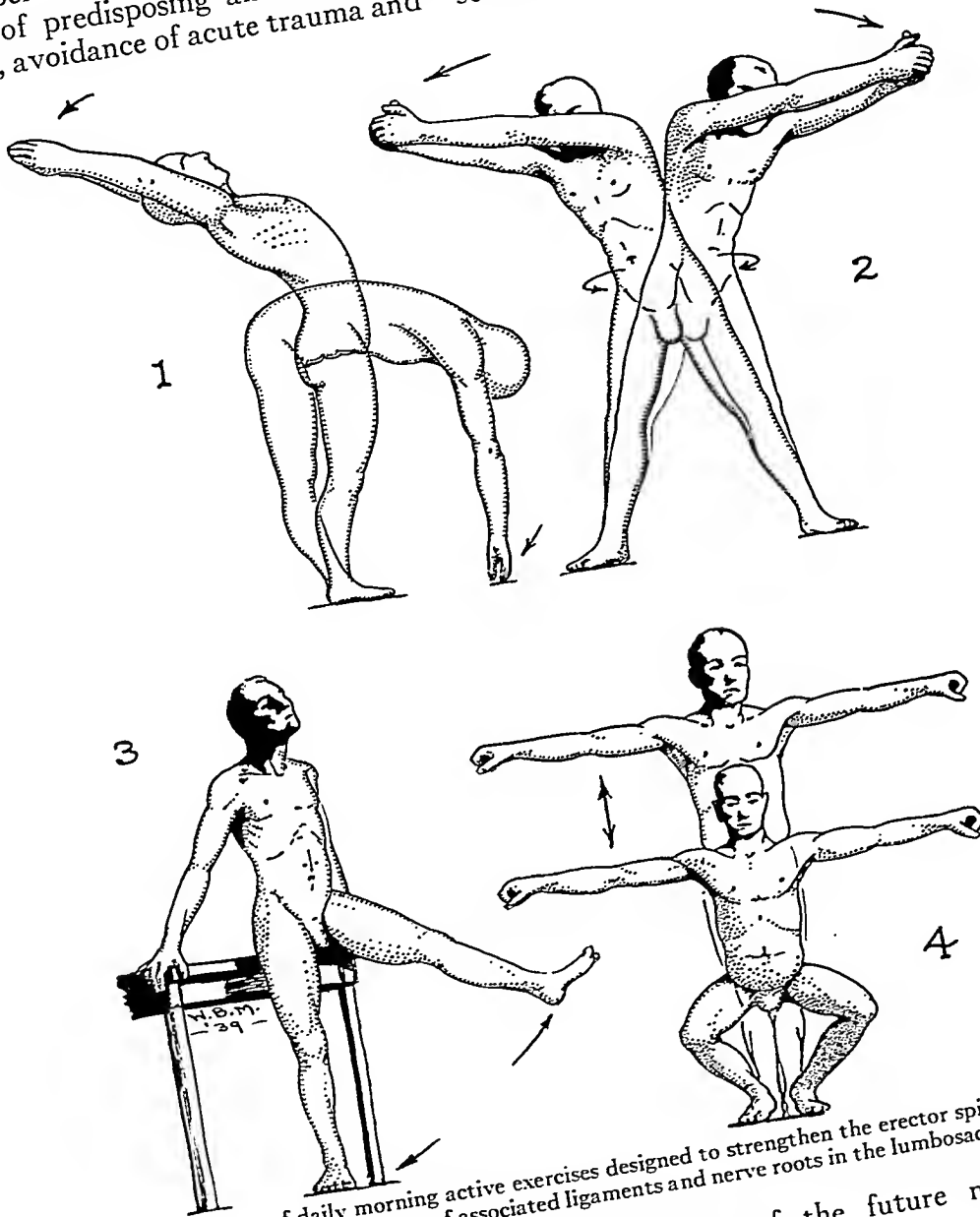


FIG. 2. Type of daily morning active exercises designed to strengthen the erector spinal muscle groups and loosen adhesions of associated ligaments and nerve roots in the lumbosacral region.

methods to bring more blood to and through the secondarily fibrosed area, are the therapeutic principles underlying the treatment of chronic painful neuritis. Surgeons of wide experience<sup>5,10</sup> state that about 10 per cent of chronic sciatica cases require major surgical operations for their cure, while the remaining 90 per cent can be relieved by minor surgical procedures. These measures are now yielding such

toonist of the future may replace his doddering, bent old man by an active foxy grandpa.

Chronic lumbo-sciatica is from the standpoint of etiology and treatment a complicated entity. "It is about as logical to refer all backaches to the orthopedic surgeon as it would be to refer all headaches to the neurologist."<sup>11,9</sup> Its cause should be sought for and in most cases its treatment

carried out by that highest type of the general surgeon—an internist trained to operate. Accurate history and a thorough examination—physical, laboratory and x-ray—should precede any local treatment. Although the elimination of a local or general toxic condition may not cure the existing pain, it may prevent its recurrence following relief by successful local measures.

#### PLAN OF TREATMENT

- I. Eliminate possible etiologic factors.
  - (a) Toxic foci or sources of referred pain.
  - (b) Correct faulty posture.
  - (c) Correct flat feet.
- II. Measures to absorb local fibrosis and free adhesions.
  - (a) Heat and massage.
  - (b) Passive motions.
  - (c) Nerve stretching.
    1. Postural and open methods.
    2. Endoneural sciatic injection.
    3. Epidural intrasacral injection.

**Toxic Foci or Referred Pain.** Despite the fact that chronic cases in the aged rarely yield to any but local treatment, we are all familiar with the occasional miracle which has followed extraction of an abscessed tooth, desiccation of an infected uterine cervix or insulin therapy in the diabetic. Before beginning local treatment see that any suspicious systemic or distant local focus is put to rights.

**Correction of Faulty Posture.** Bad posture usually means functional muscular insufficiency. The slumping recruit, as his muscles develop under military drill, soon becomes an erect well postured soldier. Have the patient go through his morning course of spinal and hip flexions, extensions and torsions gradually to strengthen the associated spinal muscles and to loosen ligaments and nerve roots. (Fig. 2.) At night, one hour before retiring, have him take a few strokes on a rowing machine and a hot sitz-bath just before going to bed.

Those bending exercises which tend to give pain are the ones to be persisted in. It is a gradual cultivation of the elderly individual

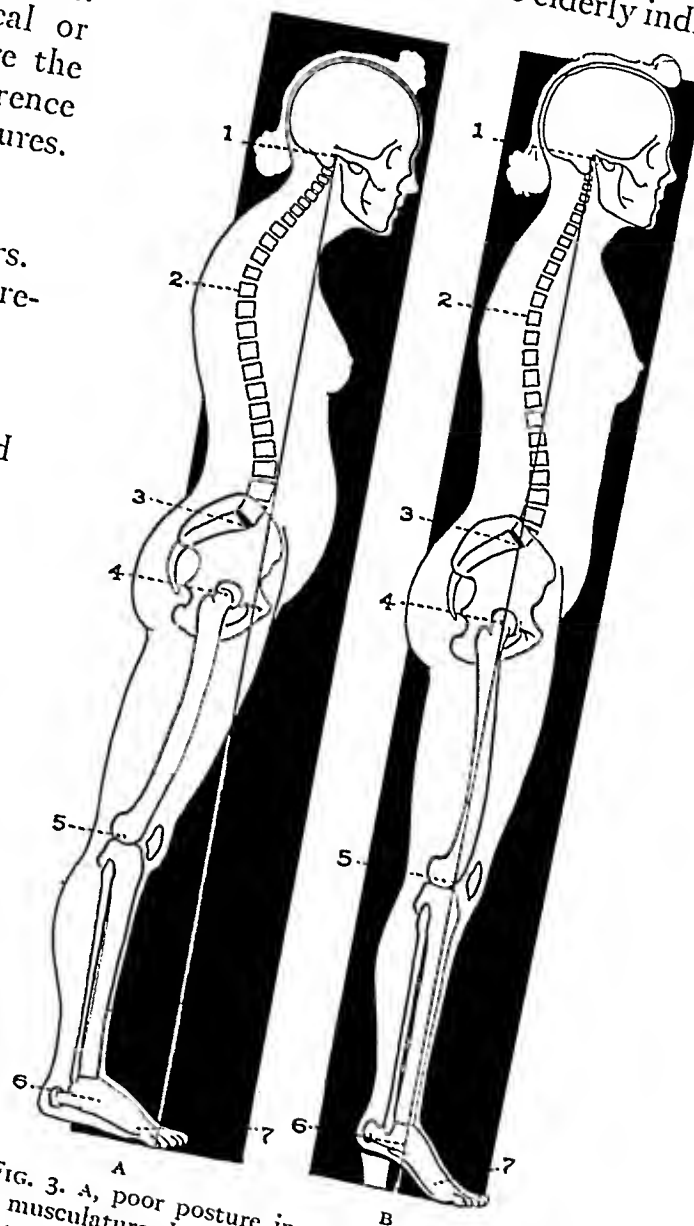


FIG. 3. A, poor posture in a woman: weak musculature, heels flat. B, improved posture by wearing moderately high-heeled shoes with broad walking surfaces. In the slumped figure, if the heels are elevated, the shoulders must go back to preserve a walking balance. (From Steel, in *New England J. Med.*, 219: 474, 1938.)

to resume the gymnasium setting up exercises of his youth. It is perhaps the most difficult part of the whole régime to enforce, for it means a bit of self sacrifice and a little real work in the naturally self-indulgent. But get the patient interested in golf and half the physician's problem is solved. The growth of our country clubs with their large middle aged membership

speaks for itself. Elimination of bed sag tends to lessen the morning back stiffness. Most patients feel best after sleeping on a

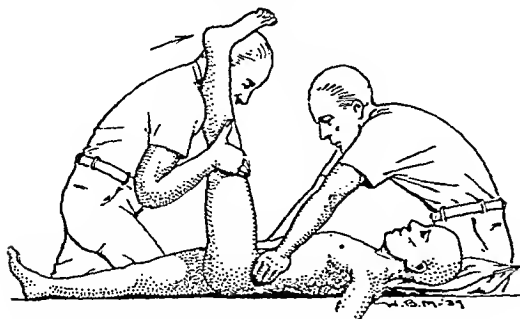


FIG. 4. Sciatic nerve stretching in the less severe case of sciatica. The patient is anesthetized. The extended leg is rocked back and forth several times until its angle with the table approaches 120 degrees.

firm hair mattress held flat by boards across the bed frame.

**Correction of Flat Foot.** This is one of the most important points in the correction of faulty posture. The flat footed individual naturally slumps forward. Put a little spring in the feet again by shoes correcting lateral and transverse arch drop and the shoulders tend to go back. Why are high heels popular with women, aside from cosmetic reasons? Because if you elevate your heels your shoulders must go back to preserve a proper balance. (Fig. 3.) Woman, with her weaker musculature, finds that she has less backache and fatigue at the end of the day, when wearing a moderately high heeled shoe with a broad walking surface.\*

#### MEASURES TO ABSORB LOCAL FIBROSIS AND FREE ADHESIONS

Irrespective of the means employed, the principle underlying the treatment of any

\* Fifty women between the ages of 35 and 55 years were questioned by us as to the type of shoes worn during their daily work. All wore some type of lateral arch support, sixteen a metatarsal pad. Forty-six wore a heel more than 1 inch high. The average heel height was 1¾ inches. Average heel width on the walking surface was 1½ inches. Forty women (80 per cent) stated that wearing sneakers or shoes with low heels for any length of time caused discomfort or pain in the feet, calves, back of thighs and lower back. Three had foot pain only; two had foot and calf pain; five had foot and thigh pain; thirty had pains in the calf, thigh and lower back. Young women generally seemed indifferent to heel type and wore with comfort whatever the occasion demanded.

chronic local inflammatory condition is to bring more blood to and through the part. Practically the whole field of modern

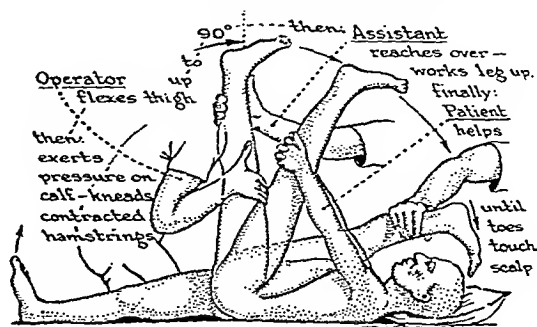


FIG. 5. Baer's complete maneuver of sciatic nerve stretching under spinal anesthesia. By a series of rocking motions carried out by the operator, assistant and patient, the extended leg is brought up until the toes approximate the scalp. Time of maneuver about thirty-five minutes.

physiotherapy is based on this principle. More blood is brought to the affected area by heat and massage, passive motions and nerve stretching. Iodine still holds its place empirically as a fibrous tissue solvent.

**Heat and Massage.** Early medical records and present habits of primitive races indicate that from prehistoric times heat and massage in some form have been used locally to allay the pains associated with chronic inflammations of muscles, joints and nerves.<sup>11</sup> Heat of any kind—sunshine, hot bath, electric pad, hot lamp, cold lamp of diathermy—holds its place as a means of temporary relief, while the hot flatiron worked over the family ironing blanket still has its rural adherents.

**Passive Motions.** Those motions directed toward breaking up a partial false ankylosis of the spinal segments, or in freeing adhesions of the spinal nerves in the intervertebral foramina have been largely responsible for the success of the manipulative cults in their relief of back and sciatic nerve pain. They should be used with caution in cases of advanced vertebral lipping and are contraindicated where x-ray shows any degree of fracture dislocation, a suspicion of tubercular or malignant disease of the spine, or disc herniation.

Bankhart<sup>8</sup> gives four manipulations carried out under full ether anesthesia. His technique is as follows:

1. Sciatic Nerve-Stretching. The patient lies on his back. An assistant steadies the pelvis. The operator holds the leg on his shoulder and

3. Spinal Rotation. The patient lies on his back. An assistant holds down the right pelvis while the operator standing on the left

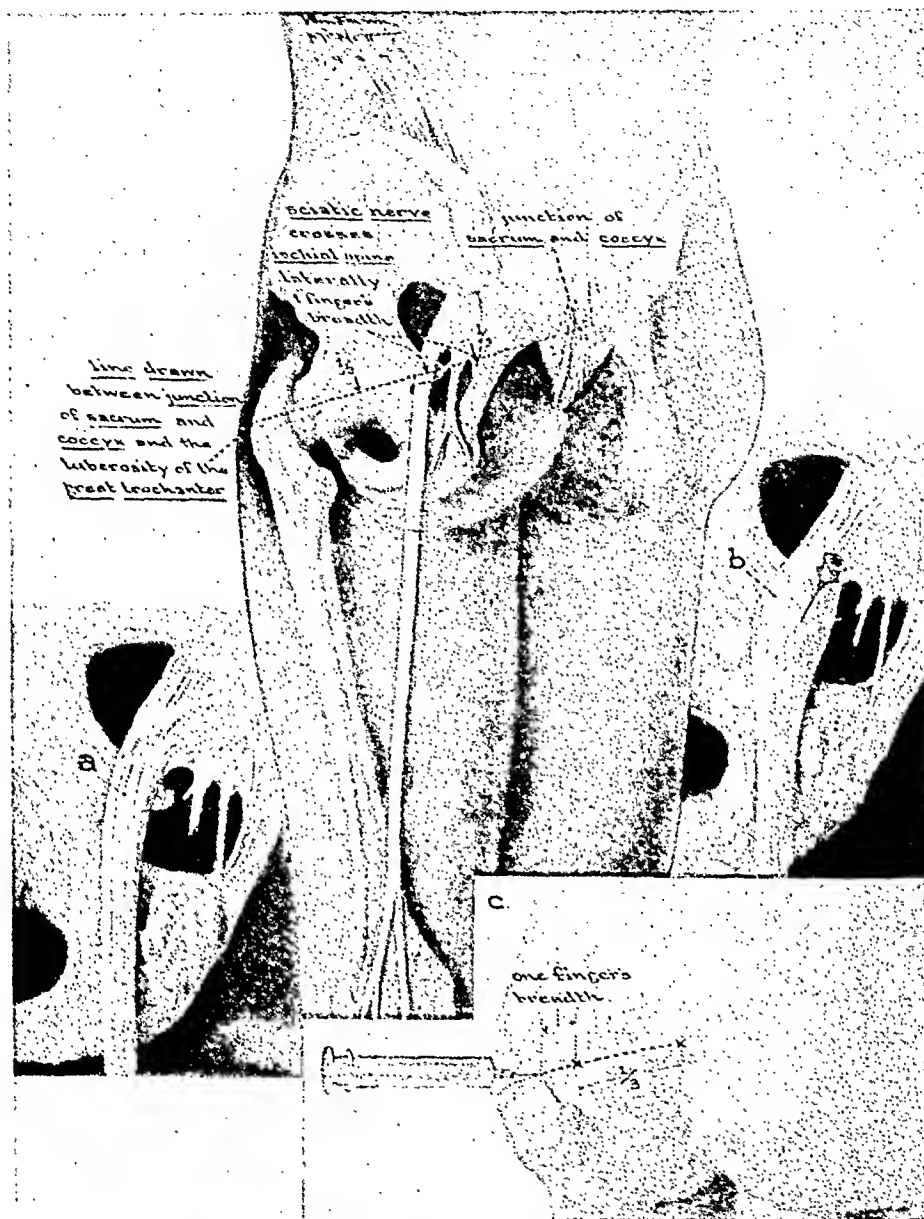


FIG. 6. Regional anatomy of sciatic nerve in the sacrosciatic notch. The surface landmark is a point one fingerbreadth to the lateral side of the medial third of a line drawn from the sacrococcygeal junction to the lower point of the great tuberosity of the femur. The deep landmark is the spine of the ischium. A, size and position of the sciatic nerve as it lies on the spine of the ischium. B, fusiform swelling of the nerve; twice normal size following the intraneural injection of 2 c.c. of fluid. C, needle plunged vertically into the soft tissues at the surface landmark. (From Steel, in *New England J. Med.*, 219: 474, 1938.)

keeps the knee stiff with one hand while the straight leg is forced up to the limit of thigh flexion and is rocked back and forth several times. (Fig. 4.)

2. Spinal Flexion. The patient lies on his back. The operator puts an arm under both knees and brings them up to the patient's head.

side, reaches over and forcibly pulls the right arm toward him. The procedure is repeated on the opposite side. Adhesions are often heard to crack during the manipulation.

4. Spinal Hyperextension. The patient lies on his face. The operator puts one arm under the thighs above the knees and forcibly lifts



the thighs, holding the back down with the free hand.

### Baer's<sup>12</sup> complete maneuver of sciatic

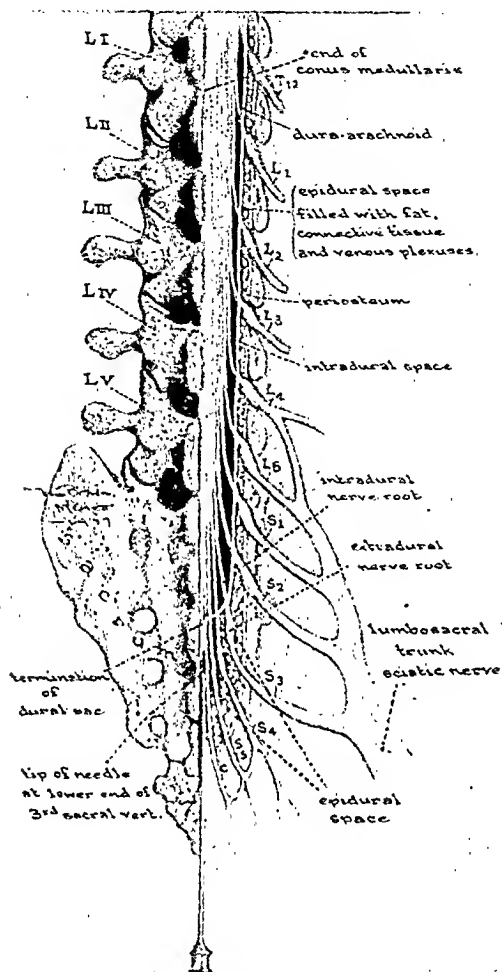


FIG. 7. Anatomy of epidural space: antero-posterior view. The space is filled with fat separating the dura from the intraspinal periosteum for the length of the spinal canal. The epidural space at the second, third and fourth sacral segments is of large size. The spinal nerves run in this space for a distance of 2.5 to 3 cm. from the point where they pierce the dura until they enter the intervertebral foramina. The needle piercing the dense sacro-cocegeal ligament for a distance of 4 cm. is well below the dural sac. (From Steel, in *New England J. Med.*, 219: 474, 1938.)

nerve stretching is carried out under spinal anesthesia as follows:

The operator stands at the foot of the table and by a series of rocking motions brings the extended leg up to 90 degrees. An assistant at the head of the table then reaches down and

helps pull the leg up toward the patient's head. The patient finally reaches down and helps pull on his foot until the toes approximate the scalp. There is a tearing sound of the hamstring fascial planes at about 120 degrees following which the leg gives rapidly. The full maneuver takes about thirty-five minutes. (Fig. 5.) A bilateral plaster cast from the costal margin to above the knees is worn for two weeks. In extreme cases a two stage manipulation is done at seven day intervals. Pain relief is usually immediate. Ecchymosis over the hamstring muscles and a transient or persistent paresthesia along the peripheral distribution of the sciatic nerve may follow.

In the less severe office type of case we have found evipal intravenous anesthesia satisfactory for a full course of manipulations, while inhalation of ethyl chloride, preceded by a sciatic endoneural novocaine injection is sufficient for nerve stretching. Severe cases are hospitalized and manipulated under spinal anesthesia. Baer's complete maneuver not only gives a complete nerve stretching but would seem to carry out all that is accomplished by the open fasciotomy operation. With the exception of sciatic nerve stretching daily active motions carried out by the patient seem clinically to give more lasting results than do passive motions.

**Direct Nerve Stretching.** The postural method has been described under passive motion. Some forty years ago exposure and stretching of the sciatic nerve in the upper thigh was a popular procedure. Enough traction was used to lift the leg clear of the table. The measure gave relief in many cases of intractable sciatica. Attempts to obtain pain relief by direct stretching of other large nerve trunks of the upper and lower extremity usually resulted in failure. Since it has been shown that it is not the peripheral stretch, but the loosening of adhesions about the sciatic spinal roots in the intervertebral foramina that brings relief, one understands why the open method has been largely abandoned. **"Intraneural Injection."** This is the injection of fluid into the nerve sheath by

skin puncture without exposing the nerve trunk by incision. The sciatic, because of its large size and accurate localization,

one finger's breadth lateral to the medial third of a line, drawn across the buttocks, from the sacrococcygeal junction to the

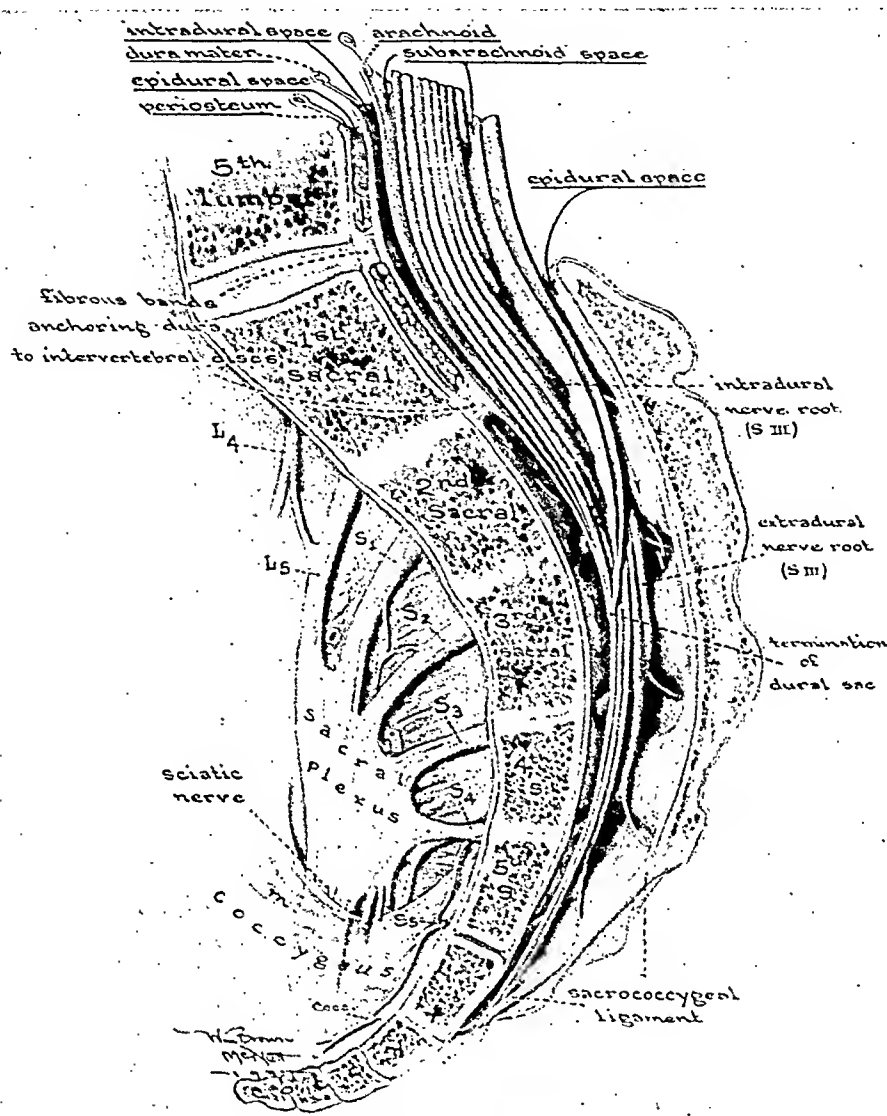


FIG. 8. Anatomy of epidural space: sagittal section. The anterior spinal roots enter the intervertebral foramina and emerge into the pelvis to form the sacral plexus. Fibrous bands anchor the dura anteriorly to the intervertebral discs. The dura is free posteriorly and laterally. (From Steel, in *New England J. Med.*, 219: 474, 1938.)

can be successfully injected. Intraneural injection results in a localized, fusiform swelling which stretches the surrounding nerve sheath and tends to separate the individual nerve bundles inside it. In experiments conducted by us it was found that injection of the sciatic nerve on the cadaver brought out the following points. In the sacrosiatic foramen the nerve rests on the spine of the ischium at an average depth from the skin of 2 inches (5 cm.). The skin puncture guide is a point

inferior tip of the great trochanter. The nerve is lifted off the spine of the ischium for  $\frac{1}{8}$  inch (0.5 cm.) by the gemelli muscles. The nerve trunk is  $\frac{3}{4}$  inch (2 cm.) in lateral diameter and  $\frac{3}{8}$  inch (1 cm.) in anteroposterior diameter. Two c.c. of fluid quickly injected into the nerve sheath causes a fusiform swelling about twice the size of the normal nerve. Excess fluid over 2 c.c. quickly leaked out through the needle puncture holes into the surrounding tissues. (Fig. 6.)

## Steel—Lumbo-Sciatica

"Technique. The patient lies on the abdomen. The skin surface guide is found, depth of 2 inches (5 cm.). Pain usually shoots down the back of the leg as the needle pierces the sciatic nerve. The

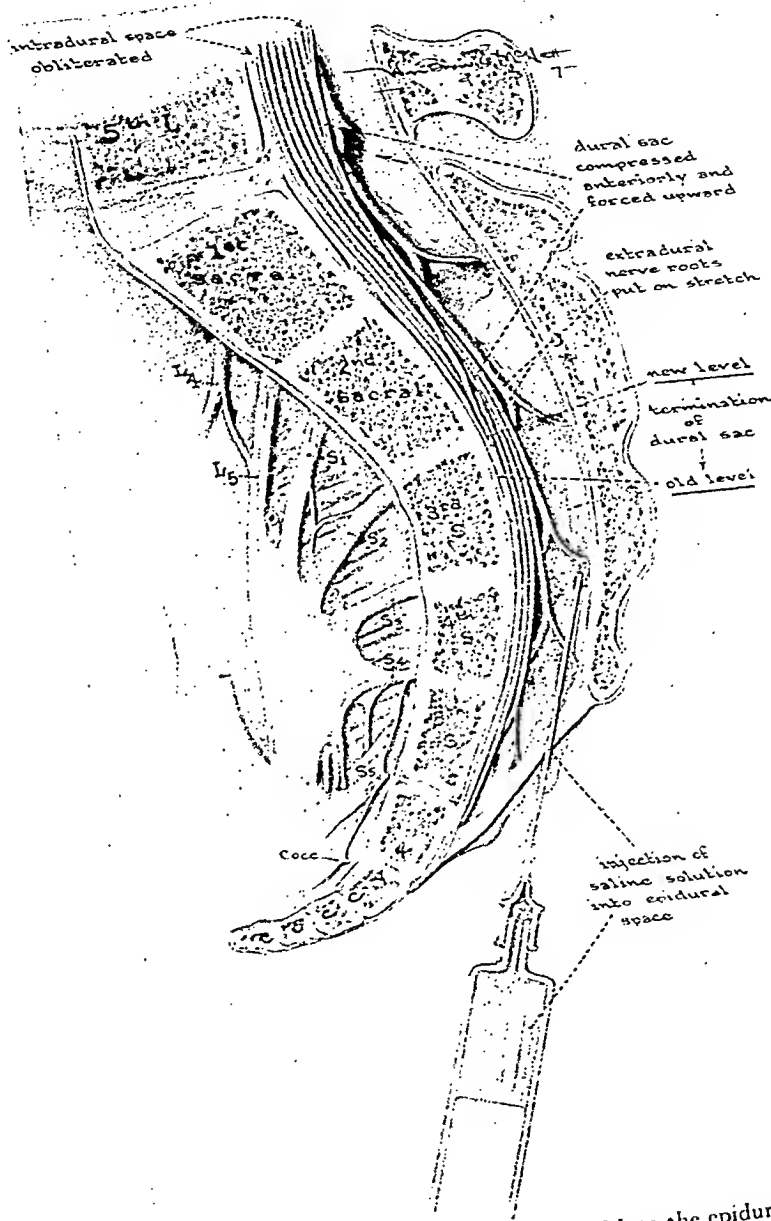


FIG. 9. Effect of injection of 30 c.c. of fluid into the epidural space. The sacral nerves and whole spinal dural sheath are compressed anteriorly and the dural sac is forced upward for 2.5 mm. This results in an intraspinal stretching of the nerve roots and tends to free adhesions in the intervertebral foramina. (From Steel, in *New England J. Med.*, 219: 474, 1938.)

thetized with ethyl chloride spray. A 20 gauge spinal needle 3 inches long is plunged in vertically, and strikes bone—the spine of the ischium—at an average needle is withdrawn  $\frac{1}{4}$  inch (0.7 cm.) to insure its point lying inside the nerve sheath. Then 2 c.c. of 1 per cent novocaine in saline is forcibly injected twice at one

minute intervals. Pain shooting down the back of the leg at the time of injection is clinical evidence that the needle point

ciate his findings, let us look at the anatomy of the spinal sheath and its nerve offshoots in the lower lumbar and sacral spine.

TABLE I  
RESULTS OF EPIDURAL INJECTION IN 75 CASES

Pain Location	Cause	Number Cases	Cure or Marked Relief	Failure
Buttock and sacroiliac region.....	Idiopathic	18	18	0
Sciatic nerve.....	Idiopathic	22	14	8
Coccyx.....	Traumatic	15	15	0
Lower dorsal and upper lumbar.....	Idiopathic	5	3	2
Malignant low back pain.....	Cancer prostate	2	0	Relief 7 to 10 days
Malignant low back pain.....	Uterine cancer	1	0	Relief 7 days
Malignant low back pain metastatic.	Cancer of breast	2	Relief—5 months Relief—10 days	2
T.B. low back pain.....	Mid-dorsal involvement	1	1 (followed by brace)	
Amputation stump through or below knee.	Endarteritis obliterans (Buerger's)	7	0	7
Nocturnal priapism.....	.....	2	0	2

lies inside the nerve sheath. Failure will result if the injection is given extraneurally or in cases of high nerve bifurcation. It is our practice first to inject the nerve; wait a few minutes, until the patient assures us that all sciatic pain has disappeared; then do a postural nerve stretching under ethyl chloride inhalation anesthesia. The patient is sent home to bed for twenty-four hours and local heat applied to the injection site. Results in twenty-five cases gave: complete relief in fourteen, partial relief in six; failure in five. Injection should never be employed in acute, fulminating sciatica.

“*Epidural Sacral Injection.* It has long been recognized that an epidural injection of 30 to 60 c.c. of a 1 per cent novocaine solution into the sacral canal to produce sacral anesthesia, is often followed by permanent relief of a chronic low backache or sciatica. Various authors advocated this procedure for pain relief. But the research work of Evans<sup>7</sup> of the London Hospital, in 1930, gave us our first true understanding of the rationale of the procedure. He showed that when 30 c.c. of fluid was injected epidurally in the cadaver a true nerve root stretching resulted. To appre-

“*Anatomy.* The spinal cord proper ends as the conus medularis at the first lumbar vertebra. The dural sac continues down to the lower border of the second sacral vertebra. The sac contains cerebrospinal fluid and the cauda equina, i.e., the lumbar and sacral nerve roots. Between the dural sac and the periosteum is the epidural space filled with semifluid fat. The dura is held ventrally by fine fibrous bands, which anchor it to the intervertebral discs. No bands bind it laterally or posteriorly. The space is prominent posteriorly at the second, third and fourth sacral segments. The space is prolonged upward in the spinal canal to the cervical region. The nerve roots run in this space for a distance of 1 to 1½ inches, from the point where they pierce the dura, until they enter the sacral foramina. The nerve roots carry a sleeve of dura out into the intervertebral foraminae. (Figs. 7 and 8.)”<sup>1</sup>

Evans’ work on the cadaver and living subject brought out the following facts when fluid is injected into the epidural space:

1. That 30 c.c. of fluid filled the sacral space. When 100 c.c. of colored fluid was

injected it could be traced up into the cervical region.

2. That the fluid filled the space posteriorly and laterally and worked out into the intervertebral foraminae between the dural sleeve and the periosteum.

3. That it forced the whole dural sac upward 3 mm. or  $\frac{1}{10}$  inch. (Fig. 8.)

4. That the slow intermittent injection of 100 c.c. of fluid gives a slowly repeated nerve stretching and tends to separate adhesions of the nerve in the intervertebral foraminae.

5. That in the living subject there was a rise in spinal pressure from 16 to 30 mm. registered on a manometer through a needle introduced into the fourth lumbar interspace, as the whole spinal sheath was forced upward and compressed.

That is, a true intraspinal nerve stretching follows intradural injection. Our experiments on the cadaver coincided with Dr. Evans' findings.

*"Technique."* The patient lies prone on the table with a narrow hard pillow under the suprapubic region. Feel for the sacral cornua. The hiatus, covered by the dense sacrococcygeal ligament, lies between the cornua and approximately 2 inches (5 cm.) from the tip of the coccyx. The skin is wiped with iodine and alcohol and anesthetized through a fine needle with 1 per cent novocaine. This needle is pushed down and through the sacrococcygeal ligament. A 20 gauge 3 inch long spinal needle is then pushed almost vertically through the ligament until it strikes bone, where it is slightly withdrawn. The butt is depressed and it is pushed up into the canal for  $1\frac{1}{2}$  inches (3 cm.). The plunger of the empty syringe is pulled out and if blood or cerebrospinal fluid appears, the needle is withdrawn until nothing appears on aspiration. Then slowly 0.5 per cent novocaine in saline is injected. The fluid should flow freely; if there is obstruction to the piston the needle point is probably imbedded in the periosteum. Withdraw it slightly and inject the fluid slowly and intermittently up to the point of referred pain. One

hundred c.c. of solution are used. Pain running out along the course of the affected nerve is a favorable sign. Swelling over the dorsum of the sacrum is evidence that the needle is outside the sacral canal. The patient rests on the table for one-half hour and is then sent home to bed for twenty-four hours, local heat being applied over the injection site for twenty-four hours. Local heat, exercises and indicated general systemic treatment, are insisted on following all minor surgical procedures. Table 1 gives results in seventy-five epidural injections given during the past 4 years."<sup>1</sup>

In 178 reported cases of sciatica,<sup>13,14</sup> including twenty-two of our own, cure or marked relief resulted in 70 per cent plus. It is worthy of note that in our seventy-five epidural injections complete back pain relief occurred in all of the cocecygodynia type and in the sacroiliac type with pain radiating down over the buttocks. It is our feeling that epidural injection, endoneural injection and postural nerve stretching offer more hope of relief in those with chronic low back pain and sciatica, who have been for months or years through the usual therapeutic mill, than any other known medical or minor surgical treatment. These procedures fail in cases of referred pain.

#### CONCLUSIONS

The cause of chronic lumbo-sciatica is usually found at or about the lumbosacral articulation as a progressive fibrosis of its related ligaments and muscles and its associated nerve roots. The condition is aggravated by acute trauma, the chronic static trauma of poor posture, local toxic foci or systemic toxemias.

The first requisites of treatment are an accurate history and a thorough physical, laboratory and x-ray examination. Any toxic focus or source of referred pain should be eliminated. Faulty posture should be corrected by progressive, active motions and proper shoes; golf is recommended for the middle aged man, and moderately high

heeled shoes for the middle aged woman. Active motion with discretion is more important than the indiscriminate rest usually prescribed.

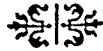
If pain persists, use in the following order:

For sciatica: endoneural injection, postural nerve stretching, epidural endosacral injection. For low backache: epidural endosacral injection and perhaps spinal manipulation. If pain still persists, some major surgical procedure by a skilled operator must be considered.

Systemic regulation, heat, massage, proper shoes and regulated exercise are essential following any minor surgical procedures. If one is looking for any specific that will cure all types of lumbo-sciatica or any one of them, disappointment is certain.

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# FRACTURES ABOUT THE ELBOW

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IN fractures of bones about the elbow the end result is very largely determined by the character of the treatment employed. Some of the most unfortunate sequelae are mute testimony to the ignorance or indifference of the surgeon responsible. Poor results are often seen in these cases despite the fact that many are in children in whom ordinarily nature is a kindly and often miraculous restorer. After an injury to the elbow the restoration of normal function requires the preservation of the contours and relationships of its several articulating surfaces. It depends also upon the amount and permanence of damage to the periarticular soft tissues and is profoundly influenced by some of the complications, as for example, ischemic contracture or ossifying hematoma which occur particularly in this region.

Of course, the surgeon cannot control the degree of original trauma and displacement, but he may exercise an influence over the reduction of bony displacements, the avoidance of secondary trauma, the early and complete resolution of exudation and hemorrhage, and the restoration of movement without impediments due to periarticular adhesions or muscle atrophy. If careful attention be given to these details the results in fractures of this region can be as satisfactory as those in any other part of the body.

This paper is not intended as a detailed analysis of the fractures occurring about the elbow. We shall present few statistics and no detailed reports. The experience of the senior author has been reported elsewhere in detail and the reader who is interested is referred to several previous reviews which are cited among the refer-

ences. The man who does a great deal of fracture work will find nothing new or startling herein, but for the one who treats fractures only occasionally and wishes to avoid complications and disappointments, we shall strive to emphasize the main practical considerations bearing upon the management of these fractures.

## ANATOMIC CONSIDERATIONS

The elbow is a complicated mechanism, providing an obvious hinge motion in which all three bones participate, and also allowing rotation of the forearm by means of the radiohumeral articulation. In so far as flexion and extension are concerned, it must be borne in mind that the arcs which form the articulating surfaces of the condyles are normally placed somewhat in advance of the humeral shaft due to a forward angulation of about 45 degrees at the lower end of the bone. If the relationship of these articular surfaces to the shaft and to each other is to be correctly interpreted from x-ray films, true lateral views must be obtained.

The trochlea projects somewhat more distally than does the capitellum, accounting for the normal valgus inclination known as the carrying angle. The maintenance of this angle is a clinical point of importance.

Several of the bony prominences are easily palpated and the presence of local tenderness or any disturbance in normal relationships is exceedingly helpful in diagnosis. The epicondyles are important landmarks, the internal one being more prominent. The tip of the olecranon can be felt even in the presence of swelling. It and the two epicondyles lie upon the same horizontal level with the elbow extended and the lines connecting the three



form an equilateral triangle when the joint is in right angle flexion. It is also helpful to remember that the external epicondyle lies in the same vertical plane as the greater tuberosity. The head of the radius may be palpated on the extensor or posterolateral aspect and may be rotated under the finger by supinating and pronating the hand. The depressions represented by the coronoid and olecranon fossae of the humerus normally accommodate the respective processes of the ulna in extremes of flexion and extension. Any alteration within these hollows inevitably limits these movements.

Although the osseous relationships are important certain soft tissue structures deserve equal consideration especially since they cannot be visualized on an x-ray film. The synovial membrane of the joint will be torn in those fractures which enter the joint, and may be severely contused by any injury in this region. Joint effusion is thus an early complication and chronic synovitis a late sequel. The envelopment of the head of the radius by the orbicular ligament has familiar implications. The insertions of the triceps, biceps and brachialis anticus into the radius and ulna as well as the origins of the flexor and extensor groups from the supracondylar ridges all have a bearing on reduction and upon the position chosen for maintenance. The cubital space, a closed compartment between the anterior capsule of the joint and the lacertus fibrosus or expansion of the biceps tendon, contains the brachial vessels or their branches, the radial and ulnar, as well as the median nerve. The possible effects of tension or compression of this compartment are matters of movement. The ulnar nerve, winding about the internal condyle on its course to the forearm, may be traumatized at the time of injury or become involved in callus later.

#### SUPRACONDYLAR FRACTURES

This is the most commonly encountered fracture in the elbow region and 84 per

cent of our cases have been in children under 10 years of age. The usual supracondylar fracture occurs at the point where the bone takes a forward inclination at a level which is further weakened by the thinness of the bony septum between the coronoid and olecranon fossae. A variation sometimes observed is a fracture line at a slightly lower level passing transversely through rather than just above the condyles.

Since the findings and management of both diacondylar and supracondylar fractures are essentially the same, they will be considered together. Usually the injury results from a fall upon the outstretched hand with the elbow extended. The line of fracture is oblique, running from the anterior surface of the bone upward and backward. Displacement of the lower (condylar) fragment is correspondingly up and back and sometimes laterally as well. Infrequent cases are seen, more often in adults rather than children, in which a reverse displacement is encountered. Only about 6 per cent of supracondylar fractures are of this "flexion type" and this small group will, of course, require management different from the others.

The deformity usually is quite obvious although its details may be obliterated by soft tissue swelling which rapidly reaches striking proportions. The arm is actually shortened and the forearm appears to be. There is a conspicuous abnormal curve of the posterior aspect of the arm. The three bony prominences formed by the epicondyles and the olecranon can be felt in their normal relationship to one another which excludes a posterior dislocation of the elbow. The lower end of the upper fragment can be palpated as a fulness beneath the biceps tendon. Abnormal mobility at the fracture site can usually be demonstrated although its elicitation, like that of crepitus, may cause so much pain that it is not justifiable.

The presence of swelling must never be used as an excuse for delaying reduction since a gentle manipulative procedure is

## Eliason, North—Elbow Fractures

the best means of reducing the fracture. It is better, of course, to obtain reduction before swelling occurs and hence every fresh supracondylar fracture should have emergency treatment. General anesthesia is essential since the tension already present in the soft tissues precludes the use of local infiltration, and brachial plexus block is hardly practicable in patients of the age usually encountered. The fluoroscope, although not indispensable, is of great assistance and saves much valuable time in securing satisfactory position. The lack of facilities for taking an x-ray should not cause delay.

Reduction is done by grasping the forearm with the elbow flexed at right angles while an assistant makes counter-traction on the upper part of the arm. The fragments are first freed by hyperextension and then approximated by making traction upon the forearm and pressure backward upon the upper fragment. The next step is to determine the position required to maintain reduction. Hyperflexion is usually necessary since in this position the coronoid is wedged into the coronoid fossa anteriorly while the triceps tendon and fascia form a hammock-like support posteriorly. However, even with hyperflexion, the condylar fragments will sometimes rotate independently of the shaft when the forearm is brought across the chest for the purpose of employing a sling. In this event the lateral hyperflexed position must be used, the hand being approximated to the shoulder of the same side, the forearm and arm thus being maintained in the same sagittal plane.

## COMPLICATIONS

Volkman's ischemic contraction is a complication especially to be dreaded. This crippling paralysis and contracture results from interference with the circulation and nerve damage due to intrinsic tension or external pressure about a swollen elbow. It is seen most often in association with supracondylar fractures because of the accumulating hematoma beneath the anterior

fascia and because, unless the fragments are reduced, the hyperflexed position results in compression of the brachial artery and vein between the lower end of the upper fragment and the coronoid.

The damage may occur within a few hours and is irremediable. It does not take place without warning and can be prevented if the signs are recognized in time. A dusky cyanotic forearm suggests venous obstruction while a pallid cold hand with absent radial pulse suggests the still more serious arterial occlusion. Pain is usually severe and persistent but may be transient, disappearing as necrosis of tissues develops.

There are some supracondylar fractures in which the radial pulse is absent when the patient is first seen. Prompt reduction is called for and in most instances the pulse then returns. If it does not and color changes develop, serious consideration should be given to the operation of fasciotomy to relieve tension about the elbow. In other cases the pulse is present before and immediately after reduction but disappears when the elbow is hyperflexed. In this event the patient should be dressed in the degree of flexion which provides good radial pulsation. Every patient whose elbow is placed in the hyperflexed position must be carefully observed during the succeeding twenty-four hours. Should the pulse disappear, the forearm must be brought down to a right angle position or fully extended and elevated on a pillow. This may mean loss of the reduction, but whereas a fracture may always be reduced a second time, a Volkmann's contracture is a permanent disability.

*Ossifying Hematoma.* The hematoma at the site of a fracture ordinarily resolves without causing any inconvenience to the patient. About the elbow and particularly in supracondylar fractures the usual healing process may be disturbed by the deposition of calcium in the hematoma. This may be due to the stripping of periosteum which often occurs in these fractures. Undoubtedly there is another factor over which the surgeon may exer-

cise control, namely the injudicious use of heavy massage and passive motion during convalescence. These ill advised physiotherapeutic measures serve to disturb and irritate the normal reparative process. Furthermore, when functional progress seems to be at a standstill and x-ray reveals an ossifying hematoma, the best therapeutic course is the conservative one of rest rather than operative intervention which tends only to aggravate the condition.

*Distortion of the carrying angle* with either cubitus valgus or cubitus varus is a permanent and disfiguring if not actually incapacitating deformity. It indicates an imperfect reduction of a supracondylar or condylar fracture. It can and should be avoided.

*Treatment after Reduction.* Whatever method of immobilization is adopted attention must be given to the restoration of elbow function as soon as the danger of displacement of fragments has passed. At the end of ten days, on an average, gentle guided active motion may begin within pain limits. The patient is encouraged to move the arm once or twice and the dressing is reapplied. It is sometimes difficult to gain the confidence of children so that they actively coöperate in this, but any manipulation which causes pain will most certainly delay the child's normal recovery. Normal function should be regained after supracondylar fracture since it is not a joint fracture and the factors which may impair the ultimate result are well within the surgeon's control. The most important of these are accurate early reduction, suitable maintenance and attention to the restoration of motion maintaining complete power of flexion even at the expense of extension if necessary.

#### FRACTURES OF THE EPICONDYLES

These are uncommon, the greatest clinical importance attaching to those fractures of the medial epicondyle which complicate dislocation of the elbow. In these the small humeral fragment may be displaced into

the joint cavity where it is an obstacle to reduction of the dislocation and may necessitate arthrotomy. The ulnar nerve may be



FIG. 1. Senior author's plaster dressing for the lateral hyperflexed position. (From Eliason's "Fractures of the Humerus, Radius and Ulna," D. Appleton-Century Co.)

displaced with the fragment. Uncomplicated fractures of either the medial or the lateral epicondyle may be regarded as sprain fractures of no great moment. Diagnosis is made by palpation for local tenderness and deformity. Joint motion is not affected in fractures of the medial epicondyle although it may be in those uncommon cases involving the lateral epicondyle since the latter lies within the capsule of the elbow joint. The treatment is ordinarily that of a soft tissue trauma. The epiphysis of the internal epicondyle does not unite with the rest of the bone until a rather late age and caution must be exercised in the interpretation of x-ray films lest a normal epiphyseal line be mistaken for a fracture.

#### FRACTURES OF THE CONDYLES

Ranking third in frequency among the fractures about the elbow, these are of particular interest because all of them are articular fractures, many involve growing epiphyseal regions and a certain number represent a single constituent of multiple and complicated bony injury to the elbow region.

The epiphyseal injuries present especial difficulty from the diagnostic standpoint. The interpretation of x-ray films is full of pitfalls but many of these may be avoided by making comparisons with the elbow of a normal child of the same age or, better still, comparing with the uninjured elbow of the patient.

The centers of ossification appear first for the capitellum and a portion of the trochlea during the second year. At the age of five the internal epicondyle becomes apparent. At ten the remainder of the trochlea is evident. Finally at thirteen the center for the external epicondyle may be seen and this soon unites with the centers for the capitellum and trochlea to form a common epiphysis which in turn will unite with the shaft during the seventeenth year. Thus for a brief period between the ages of 13 and 17, the three may separate as a group, leaving the internal epicondyle which unites last of all at about the nineteenth year or later.

When separation of any of these epiphyses occurs, there will be physical signs of injury at the elbow with limitation of motion but little deformity, since displacement is usually slight. True lateral x-ray films are helpful in showing a disturbed relationship of the normal forward curve of the lower extremity of the humerus. Accurate reduction should be the aim, but this does not absolutely insure against growth disturbance which may occur regardless of the accuracy of the reduction and, indeed, even though gross displacement is not present.

The prognosis should be guarded since it cannot be predicted with certainty whether the result may be retarded, excessive or normal growth. Fortunately, after the age of ten most of the growth of the humerus occurs at the upper end. In cases with considerable displacement in which closed reduction is unsuccessful, the surgeon, albeit with reluctance, must face the necessity for open operation. The best results appear to have followed simple replacement without the introduction of

foreign agents as a means of internal fixation.

A second group of fractures consists of those of the individual condyles occurring after the epiphyseal age. The external condyle is the one more commonly involved since it may be sheared off by indirect trauma, as from a fall on the hand with the arm abducted, as well as being more exposed to direct trauma. The external condyle lies almost wholly within the joint cavity, and lacking the muscular attachments which tend to retain its mesial counterpart, fragments from it may be considerably displaced. There may be rotation of these fragments. This defies reduction by closed methods and is a serious impediment to joint function unless the fragments are accurately replaced by operative means. In both condyles exact restoration of the normal articular contours is extremely important. Marked disturbance of the normal carrying angle as well as limitation of motion may follow inaccurate reduction. The majority of these fractures show no more than a slight displacement, which is indeed fortunate, for reduction is by no means easy. The diagnosis of these fractures may be inferred from the local tenderness and interference with elbow motion, but x-rays are essential to accurate diagnosis and proper treatment.

The third type of fracture in this region is that which splits both condyles from the shaft, the fracture lines describing a letter  $\tau$  or  $\gamma$ . These fractures are on the increase as a result of automobile accidents in which the victim has an elbow projecting from the car window at the moment of impact. The elbow is often shapeless, swelling is marked and palpation gives the characteristic sensation of a "bag of bones." Some semblance of normal contour can be obtained by moulding, but displacement is apt to recur as soon as pressure is released. Not infrequently the fracture of the condyles is associated with other fractures below the joint, as for instance, the head of the radius or the

olecranon. In a few instances the situation is further complicated by a compounding of one or more of the fractures. It is practically impossible in many of these cases to maintain proper alignment of the condylar fragments by any of the usual ambulatory methods of splinting and continuous traction is therefore necessary to overcome the tendency of the shaft fragment to split the two condyles and displace them laterally. The prognosis for function in these cases is not favorable under any circumstances. Operative reduction with nail fixation has been advocated, but the results have not been brilliant. Probably as good if not better elbow motion may be regained by early active movement as soon as the fragments have become fixed. This must be conducted with caution under the personal supervision of the surgeon. It is generally felt that children may be expected to regain fairly good function but actually most of the cases are seen in adults. Much of the crippling often seen after these fractures is preventable if the surgeon will take the time and effort required to encourage active motion.

#### FRACTURES OF THE CAPITELLUM AND TROCHLEA

Fracture of the capitellum is unusual, having an incidence of only about 0.5 per cent in our series of fractures. It may occur either in children or in adults. In the former the displacement is not marked, but shows as a flattening of the forward curve on the articular surface of the bone in the lateral x-ray view. It may interfere with joint movement if unrecognized, but growth disturbance need not be expected since the fracture line passes distal to that of the epiphysis. In adults the fragment is usually displaced forward into the joint cavity where it behaves as a foreign body and does not absorb. The signs suggest a fracture of the head of the radius but rotation of the forearm under the examining fingers shows that the radius is intact. X-ray examination is essential.

Our experience with reduction by manipulation has not been very successful, but the recent case reported by McLaughlin demonstrates that it can be accomplished with good results. If the fracture line extends beyond the joint confines, reduction either by closed or open methods will usually result in union. If the fragment is completely intra-articular or if closed reduction is unsuccessful, operation must be done and the fragment removed or fixed. After successful closed reduction the extremity should be dressed in the position which best maintains reduction. This frequently is found to be hyperflexion.

Fractures of the trochlea are even more unusual. The diagnosis can only be made with certainty from the x-ray film. Operative removal of the fragment should be done if a single attempt at reduction under the fluoroscope is not successful.

#### FRACTURES OF THE OLECRANON OF THE ULNA

These are common enough to be familiar to all. The line of fracture usually crosses the base of the olecranon process at its junction with the coronoid. Unlike its analogue in the lower extremity, the patella, fractures of the olecranon are rarely comminuted.

The diagnosis is readily made from the examination, which reveals local tenderness, painful limitation of flexion and extension of the elbow and a palpable defect in the bone. Even with extensive effusion into the joint the subcutaneous border of the ulna can be palpated. Since the deformity is one of separation, crepitus may often be absent. About one quarter of the cases of fracture of the olecranon have complicating fractures, more commonly of the head of the radius, the coronoid process or the internal condyle. For this reason two plane x-ray films are essential.

The indications for treatment are clear enough. With only slight separation, the elbow is immobilized at right angles and cautious exercise begun after two weeks. Union may be fibrous but satisfactory for

## Eliason, North—Elbow Fractures

use. When wide separation is present operation and suture give the best result. There may be general contraindications to an operation but efforts to approximate the fragments by means of adhesive straps or bandage are not apt to succeed and the elbow will be weakened. In compound fractures debridement and suture are clearly indicated unless the time elapsed since injury makes operative interference hazardous from the viewpoint of infection. Bone and joint are both exposed at operation and the most rigid aseptic technique is required. The procedure consists of drilling holes through both fragments for the passage of an approximating suture and closing the tear in the triceps aponeurosis.

The material chosen for suture has given rise to considerable controversy. Undoubtedly non-absorbable materials permit more early exercise of the joint but the wisdom of using a wire suture in this subcutaneous location may be questioned even though only occasionally does it cause irritation. Fascia lata is theoretically ideal, but a certain familiarity with its use is required of the surgeon. We have obtained good results with No. 1 chromicized catgut.

After operation the elbow should be fixed at a right angle until acute soreness subsides and then the forearm is carried in a simple sling while motion is being recovered by frequent periods of active movement. The disability period is usually from six to eight weeks. Dressing of the elbow in an extended position is often advocated for these fractures, but has very limited application. Obviously in the absence of separation or after operative fixation, the extended position is not required. In rare cases with moderate separation this dressing may serve to bring about approximation, but the position is awkward and cumbersome to the patient as compared with the use of a sling. Complicating fractures usually make operative suture of the olecranon imperative since only after fixation of the latter can the associated injuries be properly managed.

## FRACTURES OF THE CORONOID PROCESS

These are practically never encountered alone, but usually occur as a complication of posterior dislocation of the elbow or less often of fracture of the upper end of the radius, the internal condyle or the olecranon. Such a fracture should be suspected in dislocations which will not remain reduced. Lateral x-ray film is necessary for diagnosis. Displacement is limited by the attachments of the brachialis anticus muscle and union is the rule although it may not be osseous. Hemorrhage in the cubital fossa may ossify and this complication must be considered. The right angle position of the elbow is satisfactory for dressing in most cases, but hyperflexion may sometimes be required.

## FRACTURES OF THE HEAD OF THE RADIUS

One of the most frequent of the injuries about the elbow, it is usually encountered in adults, but may occur as an epiphyseal fracture between the ages of 7 and 14. The mechanism producing this injury is a fall upon the pronated and extended forearm. The radial head is thus driven against the condyle and crushed, or a portion of its rim is split off. Since the orbicular ligament closely surrounds the radial head, any displacement of a fragment indicates that it has escaped through a tear in the ligament and the improbability of reduction by closed means is obvious.

The diagnosis rests upon pain on supination and tenderness on the back of the forearm just below the lateral epicondyle. A fragment displaced to the ulnar side may not be palpable, but it will interfere with flexion. When there is no displacement, x-ray is essential to confirm the suspicion of fracture.

As has been suggested, closed reduction of a fracture of the head of the radius is usually not feasible. The question is whether simply to splint or advise operation. In fractures without displacement the obvious treatment is immobilization with the elbow at a right angle until the soft tissue tenderness subsides, usually a



week to ten days. Then active motion is begun. When the head of the bone is severely crushed or a fragment is clearly separated, operation certainly offers better chances for functional recovery than conservative measures.

In none of these cases should too optimistic a prognosis be given, for traumatic arthritis with painful restricted rotation may follow an apparently minor injury with or without displacement and regardless of treatment. At operation replacement of the fragment is only to be considered in cases of epiphyseal injury. If the fragment be a small one, less than a third of the circumference of the head, simple removal is probably indicated and active motion is begun immediately. If a greater portion of the head is involved not only should all loose fragments be removed but the entire head and neck resected and motion encouraged from the outset. This fracture quite commonly results in a useful elbow but not so often in a normal one.

#### FRACTURES OF THE NECK OF THE RADIUS

These are significant due to the fact that any alteration in the normal axis of the neck implies a corresponding disturbance in the articulating surface of the head. The interference with normal pronation and supination may therefore be quite as great in fractures of the neck of the radius as it would be if the head itself were directly involved. As a matter of fact fractures of the two frequently coexist, notably in those which have the characteristic "mushrooming" of the upper end of the radius. The clinical signs of the two fractures are very similar. Treatment differs in that one may expect in many cases to correct deformities of the radial neck by manipulation and thereby restore the proper articular relationships. On the other hand, if these cannot be restored, operative resection of head and neck will alone ensure normal function. As previously mentioned the prognosis following this operation should always be reserved.

#### DRESSINGS FOR FRACTURES ABOUT THE ELBOW

A good reduction is often spoiled by insufficient attention to the choice and maintenance of a suitable dressing. A common error is to assume that all fractures at a given level should be treated in the same way. This is by no means true and supracondylar fractures may be cited as an example. Two cases may present identical initial deformity yet it is found in one that when the forearm is brought across the chest after reduction the condyles undergo rotary displacement. In the other there is no displacement, the fragments remaining locked. The first of these cases must therefore be dressed with forearm and arm in the same anteroposterior plane using plaster of Paris fixation in lieu of the sling which may be quite sufficient in the second instance. Again, in supracondylar fractures deviation must sometimes be made from the usually desirable hyperflexed position, for there are cases in which hyperflexion may displace the fragments or soft tissue swelling may dictate that the elbow be dressed at a right angle rather than in hyperflexion.

The dressing is after all only a means adopted to maintain the reduction, insure comfort to the patient and avoid complications. It should be suited to the individual and not the reverse. Accordingly, in discussing the various fractures of this region, we have refrained from making any dogmatic statements about the style of splint or dressing which may be required. The decision must be made by the surgeon according to the particular requirements presented by the case and often he can make this decision only after he has reduced the fracture and observed its behavior under the fluoroscope.

There are in general four alternative positions in which one of these fractured extremities may be placed while the patient remains ambulatory.

1. The elbow flexed to a right angle and the forearm carried in front of the body



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and supported by a sling. In the vast majority of cases it suffices to have the forearm in the midposition as regards rotation but occasionally pronation or supination are required.

2. The elbow hyperflexed so that the hand approaches the shoulder of the same side and the forearm and arm rotated as a unit across the chest. This is the so-called anterior hyperflexed or Jones position.

3. The elbow hyperflexed with the forearm in the plane of the arm without rotation. This is the lateral hyperflexed or Eliason position.

4. The elbow in extension or semiextension.

In certain instances it may appear obvious to the surgeon that none of these ambulatory dressings will be satisfactory and that continuous traction and suspension in bed is necessary. This may be dictated by the inability to retain the fragments except by constant traction, by the excessive swelling of the soft parts, or by the presence of a compound wound or by other equally good reasons. A fifth form of dressing has thus to be occasionally considered.

The right angled position and sling suspension may be called for in a variety of fractures with little or no original displacement. It finds common usage with fractures of the head and neck of the radius, the coronoid, the olecranon after open reduction, and in some of those involving the condyles. The position may be maintained in a variety of ways. A simple triangular sling may be sufficient or it may be used in conjunction with an internal right angle or an anterior right angle splint, either of which may be of wood or of plaster reduplications moulded to the part. We make frequent use of moulded plaster splints, but do not look with favor upon the use of circular plaster casts in the treatment of injuries about the elbow. If full pronation or supination of the forearm is required, as it may be in rare instances of fractures of the individual

condyles, a well fitted plaster mould will retain the desired degree of rotation far more satisfactorily than any ready made splint of wood or metal.

The anterior hyperflexed position finds its most frequent application in supracondylar fractures but may also be useful in those involving the condyles separately, the capitellum, the trochlea and occasionally the coronoid. It may be the simplest sort of halter which may well be described as a collar and cuff sling in which the wrist is suspended at the level of the suprasternal notch. Uncomfortable pressure may develop at the back of the neck and over the ulna and these parts should be padded. Our custom is to thread the muslin bandage which is used for the sling through two lengths of soft rubber tubing. The patient should be shown that slightly elevating the wrist with the other hand and thus shifting the position of the tube will relieve this pressure. It is surprising how many patients are afraid to do this unless instructed by the surgeon. The skin in the flexion crease may become chafed and should be cleansed and dusted with powder daily.

Many patients or more especially their parents are disturbed because the site of fracture is not covered by this dressing. Actually this is not necessary as the condyles are wedged between the coronoid in front and the triceps expansion behind. An encircling bandage or a compressing splint about the elbow is apt to do more harm than good by interfering with circulation. Usually swelling subsides rapidly after an accurate reduction but blebs may appear and require attention.

Extreme hyperflexion is rarely needed for longer than a week or ten days at the end of which time the wrist is gradually lowered. At each adjustment of the dressing the range of motion within pain limits is gently tested and if complete flexion becomes difficult the forearm is returned to the hyperflexed position for a few days.

The lateral hyperflexed position, as has been noted, is used in those instances in

which rotation dislodges the fragments. We use it in about one out of every three cases of fracture through the supracondylar level or the condyles themselves. Some have advised an encircling strip of adhesive or a bandage about the forearm and arm with the elbow hyperflexed but this is open to the objections mentioned to any encircling bandage about the elbow. Our preference is for an anterior plaster splint moulded carefully about the forearm and arm and reinforced by several turns of plaster which begin in the interscapular region, pass forward over the shoulder, downward on the inner side of the hyperflexed elbow and then swing across the ulnar aspect of the forearm to encircle the chest. During the application of this dressing, which is shown in the illustration, care must be taken not to rotate the forearm from its position directly in front of the arm and shoulder. If care is taken to cut away the lower edge of plaster the flexion crease can be exposed for care of the skin and this also permits good lateral x-ray films to be taken by introducing a film, not a cassette, between the elbow and the side of the body. Warning must again be sounded that in using the hyperflexed position the quality of the radial pulse must be carefully observed. Our routine orders are: "Take pulse at wrist *on the splinted side* every half hour and report its absence or weakness immediately to the intern."

*The extended forearm* is a position for which there is only occasional need. Fractures of the olecranon may sometimes be so treated if operation is not done. There are also occasional instances of absent or feeble radial pulse in which the condition of the circulation is best observed by extending the forearm and elevating it on pillows. Straight wooden splints or by preference a plaster of Paris trough or gutter splint may be used.

*Traction in Bed.* The application of the traction may be by means of adhesive tape in the form of a Buck's extension, by a loop or sling of padded muslin or saddler's felt around the flexed elbow, by a pine or wire

through the olecranon or by a screw hook inserted into the ulna opposite the coronoid. With adhesive traction the forearm may be extended and the strips applied the full length of forearm and arm, or the elbow may be flexed to any desired degree by applying one extension apparatus to the arm for traction and a second one to the forearm for suspension. A flexed position of the elbow is decidedly more comfortable for the patient. If a sling or loop be used great care must be taken to prevent undue pressure and frequent adjustments may be necessary to prevent the loop from slipping down along the forearm.

Skeletal traction through the olecranon presupposes the availability of necessary instruments and appliances, a careful aseptic technique in the introduction of the pin or wire and due care to avoid injury to the ulnar nerve. The screw hook as advocated by Cubbins and Callahan obviates the need for much equipment and the possibility of nerve injury but it does not dispense with the necessity for strict asepsis. Having secured attachment of the traction apparatus to the patient an external fixed point of attachment is required. An overhead frame is practically indispensable but need not be elaborate.

A hard flat mattress may support the arm without angulation but this may be assured by placing fracture boards between mattress and bedspring. Particularly if the patient is obese a Thomas splint with well adjusted hammocks between the side bars is advantageous. Traction and suspension have the advantage of offering an open type of fixation apparatus in which soft tissues may receive proper care and in which light massage, heat and active motion may all be practiced early.

#### CONVALESCENT TREATMENT

This has been touched upon in the discussion which has gone before but its importance is such that it warrants special emphasis. During the first few days soft tissue swelling often is a problem even though accurate reduction does much

toward causing its recession. At this stage radiant heat and gentle stroking massage have their greatest efficacy. Unfortunately their use is all too frequently reserved for a later period of treatment. Physiotherapy should begin with the reduction of, not the union of a fracture and should be used several times a day.

Dependency of the part should be avoided if the dressing will permit and, in cases with serious swelling, irrespective of the favored dressing. Blebs should be opened under sterile precautions after which they may be covered with tannic acid if desired. The surgeon must maintain a constant alertness to the dangers resulting from the pressure of tight or rigid dressings. Attention has been called to observing the integrity of the radial pulsations.

The time for institution of elbow movement depends upon the likelihood of displacing fragments. It should begin at the earliest possible date, meaning somewhere between the fifth to the tenth day. However, as much harm may result from too strenuous movement as from too prolonged immobilization. There is an ideal mean in which function is gradually regained without the interruptions occasioned by secondary trauma. No set rules can be given, but two general principles must be followed. First, it is the voluntary active movement of the patient which constitutes the major element in recovery. The surgeon may guide movements; he may support the weight of the extremity but he can not hasten matters by forcible passive motion or stretching under anesthesia. Indeed "pump handle" methods may do much harm. The patient must be impressed at the outset with the responsibility he carries for his own welfare and his confidence and coöperation must be obtained. It is only in the patients who fail to carry out their part of the scheme that a professional physiotherapist need be called upon in this particular group of fractures. To do so is not only an admission of failure but likely to be a poor substitution for a régime in

which the patient works out his problems for himself. Second, the most reliable index of how much activity to allow at any stage of convalescence is the subjective reaction of the patient after exercise. It is almost inevitable that some pain may accompany the actual efforts to move a part which has been immobilized after injury. However, if pain continues as a persistent ache after exercise or if it is found that soreness of the part results in a decreasing rather than increasing range of motion, then the obvious conclusion is that exercise has been too strenuous or excessive and should be curtailed.

A favorable course is thus marked by the painless, progressive approach to a normal functional range. This implies the utmost gentleness in handling, no sudden jerks or forcible pressure and constant and persistent encouragement to bolster confidence and secure active cooperation. Children regain motion surprisingly if left to their own devices after danger of displacement or refracture is past. Special calisthenics are rarely needed and may be deleterious in fixing attention upon the disability. Adults may require various devices such as resistive exercises, climbing the wall with both hands, carrying weights in the hand or lifting them with a rope and pulley apparatus. The difference lies not only in the recuperative deficiencies of adult tissues but in the mental hazards, notably fear of pain and fear of further injury. In both groups continued improvement may be expected over a period of months and no functional disability should be regarded as permanent under one year.

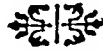
#### CONCLUSION

Fractures about the elbow require thorough and accurate diagnosis which takes the soft parts into consideration as well as the bones, accurate restoration of displaced fragments, individuality of fixation dressings and judicious therapy designed to restore function at the end of convalescence. With proper attention to these

details the results in these cases should be good with very occasional exceptions.

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It is commonly believed that the meat of young animals is more tender than that of the old. Actually the meat of the young animal is tougher. Meat is muscle, and muscles are tied up in tough tendons, sinews and other hard fibers. These tissues are indigestible. As the animal grows older and the muscles develop, the fibrous tissues thin out, making the meat more tender.

# FRACTURES OF THE CARPAL (NAVICULAR) SCAPHOID

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CARPAL scaphoid fractures are not rare, but their true incidence seems indeterminable. Experiences vary: one writer finds an incidence of 8.7 per cent among hand fractures, while a second finds a far lower incidence. The practitioners among those of youthful activity, or of youth, will present high rates, while those of a different strata will find this disorder uncommon.

The mechanics of this fracture are disputed, and for this paper we see no advantage in reviewing them. It is sufficient and necessary to know that we have a fractured carpal scaphoid. An outstretched or dorsiflexed hand, and an intolerable pressure will bring a fracturing force through the third metacarpal and os magnum onto the immobilized scaphoid. Thus a waist fracture occurs. The extra-avulsion, beautifully exemplified by the diagram illustrating the optimum x-ray position in this paper. (Fig. 2.)

The scaphoid is not well-named: the old name—navicular or "boat-shaped"—fails to describe its anatomy, for no flight of imagination will make this bone look like a boat. The scaphoid is merely an elongated carpal, angled in its long axis through a few degrees and supplying most of the keystone of this arch the wrist is very insecure indeed. Specifically, the bone consists of a body, a constricting waist, and a tuberosity, named in order from the proximal to the distal ends. The waist gives insertion to the radiocarpal ligaments and entrance to a varying number of blood vessels. Oblentz and Halstein (1938) find that 13 per cent have all their vessels at this constricted area; so fractures above

the level, if we can believe the ischemia theory, are destined to nonunion in exactly that number. Lutzeler (1932), with equal emphasis, finds a proximal and distal blood supply, and no vascular reason for nonunion.

The five articulating surfaces of the carpal scaphoid leave little room for active osteogenic periosteum and hence little space for cortical bone repair. The physiologic senility of the wrist through its constant activity cannot encourage bone repair. The peculiar differentiation of the wrist synovia toward uncontrolled pannus formation hardly assists cartilage restoration or rehabilitation.

In discussing carpal scaphoid fractures we must first arrive on a common ground. Is the fracture through the tuberosity, the waist, or the body? If it is through the tuberosity we can practically neglect it, for it will heal. If it is through the body it will not heal easily. It is small wonder that nearly as many treatments exist for fractured carpal scaphoids as there are many conflicting results. If one speaks only of tuberosity fractures, all results are good; however, here we will speak only of waist or body fractures.

Why is this fracture troublesome, and why is it slow in healing? The theories are here shown—finally to be forgotten, since all we want is a painless wrist or bone union.

The first of the theories is embarrassing of the blood supply—Leriche and Policard (1928) maintain that this is a requirement of bone union. The next is the interposition of the radial-carpal ligament; Burnett feels that Adams is wrong in this. The constant bathing of the

fracture line by the physiologic lubricant-joint fluid may contribute to delay—although Johnston is erroneously believed

longed “wrist sprains.” Others will not be seen on the first x-ray plate and will be found only after rarefaction occurs,

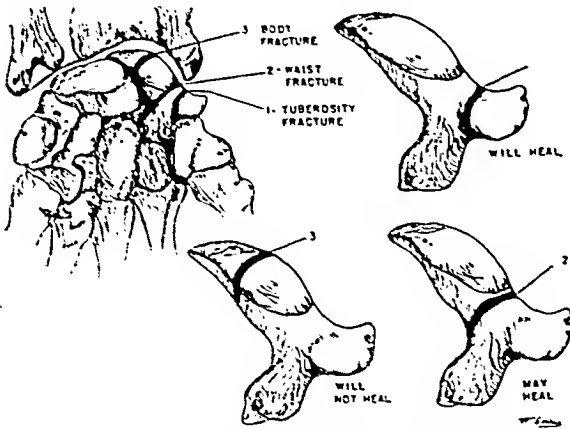


FIG. 1. Carpal region as viewed from palmar side. 1, Dark line indicates fracture through the tuberosity which heals with little or no treatment. 2, Line indicates fracture through the scaphoid waist which may heal with little treatment. 3, Line indicates body fracture which will heal only under nearly ideal conditions.

to have shown this wrong. Johnston has shown how little the periosteum functions in the scaphoid region. Certainly, lack of fixation can be regarded as the least common denominator of all nonunions; on this must we pin our faith, and against this must we direct our treatment.

If we regard the carpal scaphoid mechanically, we will see that a great stress is brought in its upper pole. Here the wrist joint pries against the fragment, while the distal end of the scaphoid is fixed firmly between the os magnum and the radius. Motion, therefore, is most marked in the upper pole of the scaphoid, and here most nonunions occur.

Despite the effect of other and more nebulous factors, we have one firm belief: nonunion is predominantly the result of inadequate fixation, since all the mechanisms for nonunion are present in those carpal fractures which always unite—save free mobility.

In treatment, we must first find the fracture. There is no doubt, and we have some proof, that some body carpal fractures spontaneously unite. Some cases of healing are found at the autopsy table, and some are simply unreasonably pro-

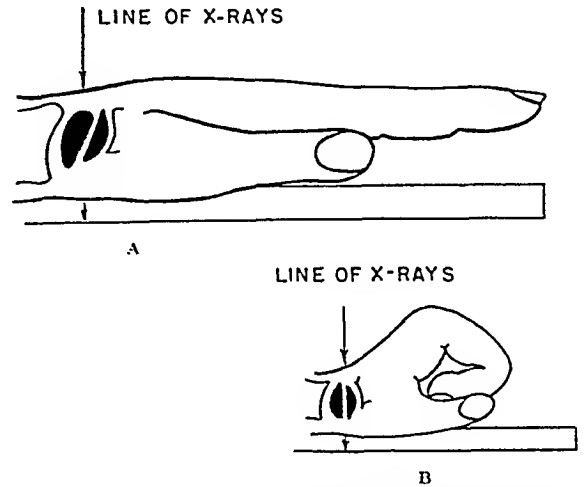


FIG. 2. A, mechanics of wrist with hand in neutral position. In this position, the scaphoid is so flexed that the fracture lines overly each other and may be missed on the x-ray plate. B, position of scaphoid with fist clenched. In this position, the usual scaphoid fracture lies in the same plane as the Roentgen rays. By using this position greater chance for fracture demonstration is possible.

while others will be suspected later by the cystic change which follows after impacted or cortical scaphoid fractures.

We recommend, and have found useful for x-ray diagnosis, the position advocated by Schnek. In this the wrist is dorsiflexed, and the hand pulled into radial deviation. This method exposes the scaphoid in its whole length, and eliminates overlying shadows. This we advocate, even if local anesthesia must be used to obtain it.

So far, nothing has been said about physical signs of early scaphoid fractures. To us they are of little importance, since wrist pain after trauma is an indication for Roentgen examination. Pain in the scaphoid region when the distal third metacarpal head is tapped, or pain over the snuffbox may indicate fracture, but only the Roentgen examination can prove it.

Before discussing treatment, we should note the possible congenital predilection toward fractures of the carpal scaphoid. Phitzner believes this, and we have evidence of this truth, since we know of four

cases of *bilateral* fracture of the carpal scaphoid. We must not be misled, however, by the bogey of bipartite scaphoids or persistent os centrales.

Although, as we have said, there are nearly as many treatments of carpal scaphoid fractures as there are frac-

5. The proximal or distal fragments may be removed, or the scaphoid may be entirely removed.

6. The center of the fractured scaphoid may be scooped out and allowed to replace itself, during a long fixation.

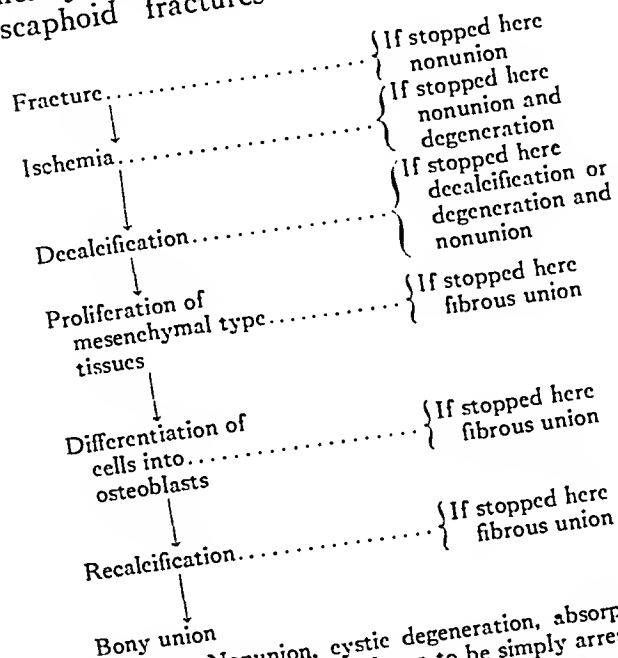


CHART 1. Nonunion, cystic degeneration, absorption, and fibrous union, are shown to be simply arrests at certain stages of the normal healing processes.

tures, treatment falls roughly into a few categories:

1. No treatment save physiotherapy.
2. Plaster fixation in volar and radial flexion (Speed); in volar and slight dorsal and ulnar flexion (Böhler); in volar and ulnar flexion (Destot); in dorsal flexion to 45 degrees with slight radial deviation (Berlin); in 30 to 40 degree extension, with the hand in complete radial flexion; and with the thumb in abduction and extension (Soto-Hall).

3. A combination of the above method supplemented by the use of a removable metal or leather splint to continue support and fixation. The time of fixation varies from three weeks to eight months.

4. The fractured scaphoid may be put in plaster in any of the above positions, and an irritant substance injected into the ancient fracture line.

Treat-ment	First Week	Later Weeks
Splint	1. Tuberosity fractures 2. Low waist fractures	1. Tuberosity fractures
Fuse or fuse and drill	1. Upper waist fractures 2. Body fractures 3. Low waist fractures, if speed is essential	1. Low waist fractures 2. Upper waist fractures 3. Body fractures
Resect degenerated portion		1. If cystic degeneration or degenerative arthritis is present 2. If arthritis of radial articular surface is present

CHART 11. Outline of treatment recommended for fractures, old and new, of the tuberosity, waist, and body of the carpal scaphoid.

7. The scaphoid may be drilled directly across the fracture line, thereby encouraging ingress of new blood vessels.

8. Autogenous bone grafts may be placed directly across the fracture (Smith, Adams).

From such a mass of conflicting treatments only confusion can come to the occasional operator. Certainly there must be some basic truths underlying these various therapies. We firmly believe the following: If the fracture is seen early, that is, within the first week, and if the break is through the waist or tuberosity, conservative treatment can be tried. Certainly the number of cures without treatment, or with seemingly inadequate fixation, confirms this belief. The exact position of this fixation seems to be of little importance, since nearly every hand position has been successfully used by different operators. It is important, of course, to reduce the fracture if the fragments have been displaced (though this is rare), and to hold them in such position as to prevent further distraction. We feel



that ulnar deviation should be avoided in tuberosity fractures, since this seems to be simply a repetition of the original methods of fracture. Dorsiflexion closes the gap between the fragments, and should the wrist become stiffened, allows the best working position. We recommend for these reasons the use of dorsiflexion and radial deviation. It has never seemed important to us to enclose the thumb, and or the index finger. The foregoing roughly sums up the so-called conservative treatment.

The fracture is held, in the case of tuberosity fractures, for three weeks in the above position. Should the fracture be through the low waist, under no circumstances should the fracture be removed from fixation in less than eight weeks, except after x-ray evidence of bone union. Some men prefer to use a removable metal splint for several weeks following the cast's removal. The necessity of this can be determined by the Roentgen plates taken during the sixth, seventh and eighth weeks.

So much for the so-called "conservative" treatment, although we should like to quarrel with the term "conservative." If an author means simply non-surgical treatment, why not state it as such? Conservative treatment, operative or nonoperative, is that treatment which will give the patient the best possible result in the shortest possible time. The above treatments apply only to low waist or tuberosity fractures seen within the first week.

All high waist or upper body fractures, or any other major fractures of the scaphoid a week or more old, except those through the tuberosity, fall in one class, and for these we believe only one treatment can be safely prescribed. Here we may well quote Todd: "One fact emerges most clearly, namely, that all methods of late treatment are uncertain and unsatisfactory." This statement, made only one year ago, must be given proper weight. The simple fixation of late or complicated cases cannot be regarded as conservative treatment; this is radical treatment, since the results are foreordained to be unsatisfactory.

In the above cases (i.e., complicated or ancient fractures) the scaphoid must be exposed surgically, and an autogenous bone graft passed through from the distal to the proximal fragment. Lately we have modified this by making several drill holes in the fragments across the fracture line, but pass the graft through only one of these. By this method we get good fixation and eliminate a possible cause of nonunion by enhancing blood supply. The hand is then put up in acute dorsiflexion and radial deviation, and is so held for eight weeks. By this method good results have been obtained in fourteen out of fifteen high carpal scaphoid fractures. Only one has shown any residual disability. Seven have united by bony union, but by reason of surgical abuse of the cartilage of the radius or because of an undiscovered arthritis present at the time of the operation, one wrist is limited to 50 per cent of its motions and is painful on attempted motions beyond those points. Such a fracture, were this cartilaginous damage and this injury found at the time of this operation, would have been better treated by removal of the proximal fragment. In other words, if a degenerative type of arthritis has already set in, no bone grafting or drilling will restore such a wrist to normal.

If one wishes to be absolutely certain of the result in waist fractures, then, even though these are less than a week old, he should join the fragments with a bone graft. This gives the patient the best possible chance for recovery. If the fracture is through the body, bone grafting should be done immediately. If the fracture is more than one week old, and is anything but a simple tuberosity fracture, bone grafting should be done. For ancient ununited fractures, with a degenerative arthritis, only removal of the proximal fragments will permit a cure. In all other fractures, simple fixation will be sufficient.

#### SUMMARY

1. It is intended in this paper to divide scaphoid fractures as to age and location,

i.e., they are either less or more than one week old—and fractured through the tuberosity, the waist, or the body, and are or are not the site of a degenerative arthritis.

2. A reliable and positive x-ray method for detecting these fractures is shown.

3. We advise plaster or splint fixation only in tuberosity fractures, regardless of duration.

4. In low waist fractures, we advise or tolerate plaster or splint fixation in those less than one week old.

5. Drilling and bone pegging are used in all high waist and body fractures regardless of age—unless degenerative arthritis has already set in.

6. Resection of the degenerated fragment is done in those fractures already afflicted by degenerative arthritis.

7. Finally, in any case of fractured carpal scaphoid, when speed and assurance of a good result are necessary (except in those fractured through the tuberosity or those who have already developed a degenerative arthritis), we unqualifiedly advise bone drilling and grafting of the affected carpal.

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# THE DIAGNOSIS AND TREATMENT OF FRACTURES OF THE PELVIS AND THEIR COMPLICATIONS\*

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OUR primary object in this presentation on the subject of fractures of the pelvis is to point out the essential features embodied in the recognition and treatment of a major surgical problem. A comprehensive review of 255 cases treated on our service since 1916 has provided ample opportunity for study of this condition in all its phases. The increase in number, occasioned by new methods of transportation and other recent industrial developments, no longer places this type of injury among the rarer fractures. Recent surveys show that it constitutes over 3 per cent of all skeletal fractures.

The normal anatomic relationship of the pelvis in maintaining its specific functions of the body is so well established and so important that any disturbed continuity of its parts should receive every effort for restoration of good alignment. The amazingly high mortality, which varies from 10 to 30 per cent, should attract the attention of the entire medical profession.

Successive advances in surgery have been followed by improvements in the mortality rate of this injury during each decade. A review of the literature by E. P. Quain in 1916 showed that prior to 1890 the mortality rate was 86.7 per cent; from 1890 to 1905 this dropped to 48 per cent and from 1905 to 1916 to 38 per cent. A recent review shows a consistent improvement, especially among the larger clinics, where clinical facilities undoubtedly offer better opportunities for the institution of proper therapy.

Much can also be said of the increased knowledge pertaining to the early recogni-

tion of this type of fracture and the establishment of first aid service for safe transportation.

Restoration of function in fractures of the pelvis is so important in order to avoid disturbed function of the neighboring viscera, that one should have a clear understanding of the essential purpose and the position which the pelvis occupies in the anatomical structure of the human body.

The pelvis is composed of the innominate bones on either side with the sacrum and coccyx posteriorly. It is divided into two chambers, the false pelvis above the iliopectineal line and the true pelvis below. It serves the very important task of protection and support of the pelvic and abdominal viscera, and also as a connecting link between the trunk and the lower limbs. It serves as a weight bearer between the trunk and the lower limbs, in addition to supplying means for locomotion. It also affords points for the attachment of the many muscles and ligaments, which control the movements of the lower limbs, which, under normal conditions, maintain proper balance and equilibrium of the body. The pelvis supports the trunk in two postures, standing and sitting. In the standing posture the weight is transmitted through the acetabulum, and in the sitting posture through the tuberosities of the ischium.

The bony pelvis is composed of two main arches, the femorosacral and the ischiosacral. These are further strengthened and anchored by two subsidiary arches,

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which join the extremities of the main ones.

The configuration of the pelvic ring presents points of special weakness, which are situated as follows: (1) midway between the symphysis pubis and the acetabulum; (2) the symphysis pubis; and (3) a trifle external to both sacroiliac joints. These areas seem most susceptible to the strain of violence and a solution of continuity is found most frequently in these locations.

It is by virtue of experience from year to year, by knowledge obtained from the literature and, by contact with others, that improvement is attained in the early diagnosis and treatment of such major injuries as fractures of the pelvis. By the same token, a reduction in the permanent disabilities and mortality rate can only be obtained by an earnest effort of the surgeon and his well organized associates in recognizing fractures of the pelvis as acute emergency surgical problems.

In the simpler forms of fracture, involving one of the rami on either side, or a moderate separation of the symphysis, without loss of continuity of the pelvic ring, only mild physical complaints may be recorded. The patient may be capable of balance and walking, but with some difficulty and pain over the inguinal region, symphysis and perineal area, and with some discomfort over the lumbosacral region. A history of some form of trauma or pelvic compression should immediately arouse one's suspicion of possible pelvic injury. A physical examination will reveal difficulty in hyperflexion of the thighs upon the abdomen, even though it may be complete and more marked on one or the other side. There may be tenderness in the perineal region, especially over the adductor muscles, with tenderness about the symphysis and along the margin of the inguinal canal. The most outstanding physical sign, and probably the most important diagnostic aid, is found upon lateral compression of the iliac crests or hip joints with the palm of the hand. One

immediately feels a giving sensation, which is not infrequently associated with crepitation. This is always accompanied by pain or distress when a fracture exists or when a separation of the symphysis has occurred. Occasionally the separation of the symphysis has become approximated, as found by x-ray. However, a positive compression sign still shows evidence of previous separation and trauma. Roentgenograms should always be taken upon the least suspicion of pelvic injury.

Occasionally intestinal ileus occurs in the milder injuries and may reach severe proportions when treatment is delayed. Its recognition depends upon the degree of distention present and whether peristalsis is subdued or absent. We always presuppose its development and institute therapeutic measures immediately.

Even though the physical findings of fracture are apparently mild, one should always be mindful of latent complications, especially those involving the genitourinary tract.

The severer forms of fracture present a vastly different picture. The symptoms and physical signs involve changes directly the result of pelvic injury plus those arising from associated injuries to other viscera. The pelvic damage may constitute only a wide separation of the symphysis with extensive soft tissue damage to the membranous or posterior urethra and surrounding structures. This may be associated with separation of one or both sacroiliac areas with or without marked displacement, or the fracture may involve one or more rami with or without displacement. Less frequent, but more destructive, is a vertical, or fracture of Malgaigne, constituting a complete solution of continuity of anterior and posterior rings, with or without displacement.

The symptoms and physical diagnostic findings in such cases usually are the following: The patient frequently presents a picture of shock in varying stages, the degree of which should immediately be determined by blood pressure readings, etc.



It may occasionally be delayed. Treatment should be instituted accordingly.

The patient is frequently unable to demonstrate proper function of one or both lower limbs by voluntary elevation while reclining. This attempt is always painful about the groin, inguinal and pubic regions. The elevation, however, may be complete, partial or absent. Observation of the pelvic structure may show a distortion, representing displacement at the symphysis, rami or posterior ring. The bladder may be found distended upon observation and percussion. The abdomen may already show a distention with apparent muscular resistance.

Lateral compression of the iliac crests or hip joints with the palm of the hands imparts a giving sensation, showing a lack of firmness and, frequently elicits a sense of crepitation which is always accompanied by certain degrees of pain and discomfort. Gentle palpation produces tenderness along the inguinal canal, the symphysis and the perineal region, occasionally over the bladder, buttocks and sacroiliac regions. The abdomen is generally resistant, but localized tenderness is rare unless some intra-abdominal injury has been sustained. Auscultation reveals subdued or absent peristalsis, indicating the presence of a paralytic intestinal ileus, especially in severe types. This is frequently mistaken for ruptured viscus.

Rectal examination may occasionally show pressure of a fragment upon the rectal wall or a rupture by a sharp spicule of bone. The patient is often temporarily unable to void even in the absence of any urethral damage. When urethral damage is present, in the form of either moderate laceration of the mucosae or rupture, there always appears some evidence of blood at the urethral orifice. This is a valuable diagnostic aid. Further investigation as to the extent of damage should then be performed by catheterization under strict asepsis. Extravasation of hemorrhage or urine into the surrounding soft tissues may occur gradually or rapidly and its diffusion

depends on the point of rupture above or below the fascial planes of the pelvis. Evidence of its presence may be observed over the bladder and lower abdominal wall, perineum or scrotum. Cellulitis following the extravasation of urine may extend rapidly over the above regions with febrile symptoms and acute toxemia.

Evidence of gas bacillus infection, developing after a rupture of the rectal wall, which develops at an early date, should always engage one's thought following the early hours of injury. The presence of a bluish-brown, discolored form of cellulitis of the skin and subcutaneous tissues, spreading over the perineum, scrotum and abdominal wall, with emphysema present upon palpation, and associated acute toxic symptoms, point definitely to its presence.

Intraperitoneal rupture of the bladder is always associated with distention and ileus and other definite findings pointing to a peritoneal irritation. The muscles, in the early stages, are palpated easily but shortly become resistant and rigid with the presence of fluid in the flanks in contrast to the physical findings of paralytic ileus. Abdominal paracentesis, as advised by one writer, as an aid to diagnosis, is a dangerous procedure, and I rather feel its practice is to be discouraged, except in extreme doubt.

As a final diagnostic measure, one can always obtain definite information by simple aseptic catheterization of the bladder, which will demonstrate the presence or absence of hemorrhage or instilled clear or opaque fluid as observed by x-ray examination.

A complete x-ray study should be had immediately, providing the condition of the patient permits. A portable x-ray, however, is often sufficient for a preliminary study.

Fractures of localized areas of the pelvis, not involving the pelvic ring, show rather distinctive physical signs and symptoms. The more common ones, involving the spines, iliac crests, or tuberosities of the ischium show local trauma with pain, ten-

derness, crepitation, ecchymosis and local mobility. Fractures of the floor of the acetabulum may be complete or incomplete, associated with limitation of motion, with pain of the affected leg, obliteration and flatness of the natural round contour of the affected hip, depending on the degree of depression. X-ray will complete the diagnosis.

Fractures of the rim of the acetabulum are rather infrequent and are difficult at times to diagnose early and correctly even by x-ray examination. Fractures of the inferior margins are less difficult to recognize and less dangerous from the point of view of return of function. Fractures of the superior margin, however, are frequently mistaken for hip joint dislocations, due to the failure of observing the hidden and displaced fragment of the superior margin of the acetabulum. One should always suspect the latter following a history of hip joint injury upon a failure to maintain reduction of a supposed dislocation of the hip joint. Fractures of the sacrum are infrequent and in the absence of displacement present only moderate local discomfort without, as a rule, nerve injury.

A recent study of our cases since 1916 discloses some very interesting facts concerning the care and management of fracture of the pelvis. We believe that an important factor in the initial period in the treatment of such fractures begins with the first aid rendered. The balance between death and recovery frequently depends upon the ability of the attending physician to recognize immediately a surgical problem and immobilize the parts for safe transportation to a hospital for immediate care. Delay in apparently innocent and simple cases frequently has permitted shock, ileus, perivesical and urethral injuries, and infections to develop so rapidly that some cases are hopeless upon admission to the hospital.

Within the past fifteen years an organized effort among the local physicians of our own industry (Pittsburgh Coal Company) has been made to facilitate proper

first aid attention at the place of injury. Patients are immediately fixed to an improvised cushioned rectangular body splint for transportation and are well protected by blankets. Such splints and other first aid equipment are available every 1000 feet throughout each mine. Upon the arrival at the entry to the mine, the patient is placed in a warm first aid room for observation. Such further temporary attention is rendered by the local physician as he may deem wise for safe transportation to the hospital. The dangerous complications which may be avoided by the institution of such methods can be readily appreciated.

Upon admission to the hospital the patient receives the immediate attention of one of our service. A careful preliminary examination is made to ascertain the nature of the injury, the degree of shock, the blood pressure and associated injuries and complications.

If the fracture proves to be of a simple character and is confined to the pelvis without complications, an x-ray is taken immediately without removing the patient from the carriage. He is thereafter placed cautiously upon a firm flat bed so as to reduce further trauma to a minimum. An adhesive extension, as a temporary immobilizing measure, is applied to both limbs, in a position of moderate abduction. The patient is suspended upon a hammock, cushioned with lamb's wool and controlled by weights and pulleys, so adjusted, by a spreader, as to regulate lateral compression. A pelvic support of adhesive or a canvas belt is applied according to the findings of the individual case. The patient is then observed carefully for further developments.

It has been our practice to anticipate the development of intestinal ileus. The routine orders, unless especially contraindicated, are immediately recorded as follows: The administration of cascara pills, 15 gr. t.i.d., followed by an enema, consisting of soap suds, glycerin and sodium bicarbonate; the restriction of fluids by

mouth; and sedatives at night for rest. This treatment is usually sufficient for the mild forms of ileus. In the more severe cases, particularly those which persist for more than twenty-four hours and continuously progress, we resort immediately to turpentine stupes, surgical pituitrin, physostigmine, pitressin and prostigmine, followed by enemas at the appropriate time. All fluids by mouth are restricted to avoid aggravating an already disturbed gastrointestinal tract. Dehydration and the loss of chlorides are balanced by careful intravenous and subcutaneous administration of dextrose saline solution in quantities to meet the demand. The use of the Wangenstein suction drainage apparatus for gastric and upper intestinal distention is occasionally resorted to and at times serves a valuable purpose. It has been necessary in certain cases to resort to intraspinal and paravertebral injections of novocaine. Continuous oxygen inhalation is helpful. The establishment of such prophylactic therapy for ileus has reduced this complication, within recent years, to a minimum, and as a result, there have been no fatalities from this complication since 1926.

In the more severe forms of fractures with displacement we are guided chiefly by the x-ray findings. Reduction and apposition of the fragments can be accomplished frequently if attempted early by gradual and gentle manipulation and traction, at times under mild anesthesia. Reduction can then be maintained by adequate fixation.

The complications of fractures of the pelvis, as well as the concomitant injuries, are usually severe. They play an important rôle in the high mortality rate and constitute emergency surgical problems, demanding the immediate attention of an experienced surgeon. Delay and inexperience are attended by tragic results.

The most frequent and important complications, which merit a brief discussion, are: shock, ileus, hemorrhage, rupture of the rectum, urogenital injuries and infections.

Shock is one of the primary and major complications in all fractures of the pelvis. This factor comprises the highest figure in the actual cause of death in this series—45.7 per cent. Shock in simple uncomplicated pelvic fractures does exist, but it is usually mild and responds rapidly under treatment. When it occurs in a severe form, it is usually associated with grave complications or concomitant injuries, such as crushes of the thigh, vertebrae, chest, etc. We are ever mindful of this condition and attempt to establish the degree of shock upon first observation. The patient is handled with the utmost care and is immediately placed in bed under intensive treatment. Upon recovery, the patient is given further surgical care without delay.

Ileus, which was discussed above, was noted in various degrees in the majority of cases. Certain patients presented a delayed form of ileus, which appeared two to four days after injury. This type may become extremely severe and very embarrassing to the patient. Occasionally, a recurrent form appears, demanding return to the primary treatment. A wide review of the literature shows but little reference to ileus as an important complication and practically no mention is made of its mechanism of development as the result of trauma. Irritation of the autonomic nervous mechanism is a major factor in the induction of ileus. In this series 22.7 per cent of the deaths resulted from it.

Injuries to the urogenital tract constitute the chief surgical complication. In such cases, success or failure depends upon the time of recognition. If extravasation of blood and urine in the traumatized pelvic tissues continues for more than six or eight hours without detection, a chemical cellulitis develops with a subsequent bacterial invasion, resulting in a fulminating infection and extreme toxemia. Ascending kidney infection may arise following acute retention. Peritonitis develops rapidly in delayed conditions of intraperitoneal rupture of the bladder. These complications can be avoided by early recognition and

the proper institution of surgical measures if the problem of shock does not interfere.

The appearance of blood at the urethral orifice is sufficient warning of mucosal damage. Investigation by catheter is performed under strict asepsis and with caution to avoid further trauma. If simple laceration exists, with little or no peri-urethral or perineal extravasation, an indwelling catheter, introduced into the bladder, is usually sufficient treatment, with subsequent repair of the urethral lumen.

If obstruction is encountered, a retrograde catheterization, with suprapubic cystostomy, is our method of choice for repair of the ruptured urethra. The suprapubic incision into the bladder is made high so as to avoid a permanent urinary fistula. Care should be exercised to avoid incising the peritoneum. The urethral catheter, which extends throughout the entire channel from penis to suprapubic opening, is not fenestrated for drainage of urine but serves as a scaffold for the restoration of the urethra. Complete through and through drainage of the space of Retzius, from the suprapubic incision through an incised wound in the midperineal line immediately below the scrotum, is thoroughly established to avoid infection of the pelvic tissues. The bladder is drained independently by the introduction of a Petzer catheter, through the suprapubic opening, so as to relieve urethral tenesmus and avoid soiling of the surrounding surface of the suprapubic wound. The drainage in the space of Retzius is retained from eight to fourteen days. The urethral catheter may be safely removed in two or three weeks. A silk guide suture is left throughout the urethral canal and bladder, which facilitates the subsequent introduction of sounds. Following the reestablishment of urethral function, the suprapubic opening heals rapidly. The periodic passage of sounds, to avoid stricture, is highly essential at a later date. It is impossible to over-emphasize the importance of aseptic technique in this procedure to guard

against the development of infection. Indeed, the preliminary catheterization of patients with suspected urethral damage should be performed with strict aseptic precautions.

The first laparotomy for the repair of a rupture of the bladder was performed in Pittsburgh on January 12, 1859, by Dr. Albert G. Walter, who reported the case in the *Medical and Surgical Reporter* of Philadelphia, November 16, 1861. Dr. Robert W. Stewart, formerly Professor of Surgery at the University of Pittsburgh, did much to popularize and improve the technique of the retrograde catheterization method.

Extraperitoneal rupture of the bladder is approached and repaired by a suprapubic cystostomy with adequate drainage. The removal or replacement of protruding sharp spicules within the bladder is often necessary and should be done cautiously before the ruptured area is closed. Suprapubic and sometimes extravesical drainage is necessary.

Intraperitoneal rupture of the bladder requires, as a matter of safety, a preliminary laparotomy for removal of the free urine. The surgical repair of the lacerated bladder may be accomplished either by intraperitoneal approach or during the routine suprapubic cystostomy for drainage. If the peritoneal involvement is extensive, drainage is established and other surgical measures for similar peritoneal insults.

These cases require careful postoperative care in order that local, as well as ascending kidney infection, may be avoided. The individual should return monthly during the following year in order that patency of the urethra may be maintained and the development of stricture prevented.

The occurrence of vesical calculi following these injuries is occasionally disturbing and should receive early attention. However, this condition frequently can be avoided by careful attention to the bladder during the postoperative period. However, the bladder seldom requires care unless gross infection has occurred.

Injury to the rectum should not be overlooked. A routine examination may show the presence of sharp fragments which occasionally protrude through the rectal wall. Gentle finger pressure is often sufficient to reduce the fragment a safe distance. Occasionally complete rupture of the rectal mucosa results from the sharp spicules, and this of course requires repair. Damage to the rectum frequently offers a portal of entry for the invasion of organisms into the soft perineal tissues. The development of gas bacillus infection is a not infrequent finding which is usually fatal if not recognized early.

Pertaining to the convalescent care of the pelvis and the adjoining soft structures, it is essential to immobilize the pelvis with properly applied extensions. In simpler forms, showing only a moderate degree of displacement, a Buck's extension is applied with a preliminary application of 30 pounds weight, and the limbs are maintained in a posture of approximately 15 degrees abduction in order to avoid contracture of the adductor muscles. Where the x-ray findings point to a marked deformity, with distortion and displacement of the fragments, as in the vertical type, or sacroiliac separation with displacement, and where reduction cannot be obtained by gentle traction and manipulation, a skeletal traction apparatus, such as the Anderson outfit, has been very useful in several of our cases. Open reduction in these cases is not only unnecessary but quite dangerous and impracticable. With certain modifications, the hammock suspension, as originally introduced by Conwell, has proved ideal for comfort, sanitation, and protection. It facilitates the moving of the patient about the bed with safety. The hammock, I believe, has proved to date the most valuable agent in the general treatment of fractures of the pelvis, except in certain specific instances, where additional methods are necessary.

All patients, except those with very minor fractures, such as simple fractures of the ilium, are confined to bed at total

rest for a period of eight or ten weeks, following which the patient is confined to a wheel chair for a period of two weeks before the body weight is superimposed upon the pelvis in the erect position.

Physical therapy, including infra-red rays, massage, interrupted galvanism and diathermy, is instituted the first or second week following admission. This is continued throughout the confinement of the patient in the hospital.

Complete x-ray studies, in various postural positions, are essential to determine the progress of reduction, the development of unusual deformities and the condition of the pelvic structure upon the discharge of the patient. There are certain other sequelae of fractures of the pelvis which deserve consideration.

Malunion of the fractured bones of the pelvis, with deformation and deficiencies of locomotion and support do occur, but rather infrequently. It is surprising at times, that despite the presence of malunion, excellent return of industrial function occurs in certain of these cases. At times sufficient firm fibrous union occurs with total absence of one side of the pubic bone, yet, the counter arch is so firmly united by fibrous union, as to permit the patient to engage in the work of a miner with fair earning capacity.

In two patients, marked separation of the symphysis with fracture and displacement of both sacroiliac joints persisted. Our inability to effect reduction at the time of injury was occasioned by a severe gas bacillus infection and other injuries. A recovery from the infections resulted in both cases, but a total loss of lifting power and improper balance and locomotion persisted. The counter or subsidiary arch was effectively tied at a later date by a subsequent bone graft, which still remains viable, in the first case for seven years and in the other for three years. Complete restoration of strength and function was afforded to the pelvic structure.

Urethritis cystitis, prostatitis, seminal vesiculitis, pyelonephritis and pyonephro-

sis, which result from ascending infection and which frequently prove serious, can often be avoided by early operation and adequate drainage. The treatment of these cases, however, demands the attention of one well trained in genitourinary problems.

In our experience, persistent urinary fistula has never occurred in any cases of urogenital complications repaired by the retrograde catheterization method. The bladder incision should always be made high in the fundus of the bladder in order to avoid a urinary fistula.

Adductor disabilities can be greatly reduced by maintaining the lower limbs in a position of abduction during confinement to bed, assisted by physical therapy.

Foot drop, which occurred in two cases of this series, may assume the proportions of a permanent disability. Fixation of the foot in dorsal flexion with a removable splint, accompanied by infra-red treatment and massage during confinement to bed, the subsequent wearing of a specially devised shoe, with an attached traction apparatus, and continued physical therapy when the patient is ambulatory, have resulted in very favorable results.

Lumbar myalgia at times is persistent and difficult to obviate, yet the number of these cases has been consistently reduced following the practice of total confinement to bed for eight weeks or longer.

Impotency represents a sequela which should not be overlooked. It is infrequent in our experience, occurring chiefly in those cases associated with ruptured urethra and periurethral damage. Delayed function occurred in two cases. Abbott in his discussion on ruptured urethra is one of the few who attempts an explanation. He attributes the condition to a tearing of the greater and lesser cavernous nerves which supply the corpora cavernosa.

Fractures of the superior margin of the acetabulum with associated dislocation of the head of the femur are rare and are disabling if not corrected. In three of this series an associated dislocation of the femoral head occurred in addition to

displacement of the superior acetabular fragment. One was reduced by a lateral exposure, the other two by the Smith-Peterson approach, which simplified the operative technique considerably. In all three cases, there was a full return of function of the hip joint. Fractures of the inferior margin, the fragments of which are seldom grossly displaced, usually do very well by total rest and immobilization by the extension method.

A review of our mortality list keeps us ever mindful of the interest and desire for future improvement in the care and management of these cases. A number of the patients who died, and who are included in this series, succumbed shortly following admission. As a matter of record and study we feel they should all be included.

Total number of cases  
treated since 1916..... 255  
Average days of disability 144.3  
Total number of deaths.. 35  
Percentage of deaths..... 13.7 per cent

The causes of death were as follows:

	Num- ber	Per Cent
Shock.....	16	45.7
Ileus.....	8	22.7
Pelvic cellulitis plus one gas bacillus....	4	11.4
Ascending urinary infection.....	3	8.5
Cardiac failure.....	2	5.7
Meningitis.....	1	2.8
Hemorrhage.....	1	2.8
Total .....	35	100

#### COMMENT

1. Fractures of the pelvis are major surgical problems and should be treated in the hospital.

2. The treatment has its origin with the first aid established.

3. Sufficient period of immobilization at total rest with early physical therapy will prevent or reduce permanent disabilities.

4. Complications should be regarded as emergencies.

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5. Early recognition by the physician and surgeon is most essential.
6. An experienced surgeon should assume personal care of all complications.
7. A review of our work of fractures of the pelvis keeps us ever mindful of the importance of a sincere effort to bring about good alignment and good apposition of the fragments as a means of reestablishing a restoration of function.

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# FRACTURES OF THE UPPER END OF THE FEMUR INCLUDING FRACTURE DISLOCATIONS AT THE HIP JOINT

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## INTRODUCTION

THE unusually heavy musculature and soft part surrounding the hip joint have made the above fractures one of our most difficult problems. In view of the rapid march of time it would seem that only yesterday many of these fractures were considered to be utterly hopeless and their unfortunate victims were relegated to the list of permanent invalidism and in many instances to early death. Today our viewpoint has changed considerably. Pessimism and hopelessness have given way to optimism and hope. To what do we owe this seemingly great medical triumph?

Cordasco in his recent publication in the *Archives of Surgery* entitled "Evolution of Treatment of Fractures of the Neck of the Femur" gives an excellent chronological and historical survey leading up to the present era of progress. The innumerable contributions which he lists have all played a distinct and invaluable part in the handling of this most interesting division of medicine. Were one to select the outstanding contributions essential to this progress, the selection would indeed be difficult. Perhaps we might start with crediting Ambroise Paré as the first to recognize and report a case of fracture of the neck of the femur. Heister and Ruysch later described the pathologic appearance of this fracture as it appeared at autopsy. Sir Astley Cooper was among the first to distinguish between intracapsular and extracapsular fractures, and he pointed out the unfavorable prognosis of the former and the favorable prognosis of the latter. To Roentgen we owe gratitude and honor for his dis-

covery of the x-ray. His contribution is the most important of all. The actual visualization of these fractures has made it possible not only to correctly diagnose them but to classify them intelligently from the standpoint of treatment and prognosis. To Royal Whitman we must credit the first excellent method of reduction and fixation. Whitman stressed most energetically the importance of both the intracapsular and the extracapsular fractures. His method became a boon to thousands of aged individuals who were treated by supportive measures existing prior to his time and who had only the prospect of invalidism. To Albee we owe the credit for the autogenous bone peg employed as an internal fixation method for fractures of the neck of the femur. Albee's contribution marked a very definite advancement in the treatment of non-united fractures of the neck of the femur. To Kolodny and Wolcott we owe a most generous consideration for their valuable contribution concerning the blood supply to the upper end of the femur. And, finally, to Smith-Petersen we must give credit for establishing a method of internal fixation for fractures of the neck of the femur which has supplanted all previous methods and is primarily responsible for our present day success. Through the development of his three-flanged nail for the purpose of internal fixation the most remarkable progress has occurred. First of all it has brought to our attention the necessity of an accurate reduction. The radiologists, through Johnson, George, and Leonard, have met this challenge by improving the x-ray technique in taking lateral views of the acetabulum, the head, the neck, and the trochanteric

areas of the femur. Improvements upon the reduction methods of Whitman have been offered by Leadbetter, Snodgrass, and others. In addition, the percentage of union in fractures of the neck of the femur has increased and the mortality rate has been materially lowered.

To Hoke, Jones, and Anderson one must credit the well leg traction principle and its development which has offered us a distinct advancement in the treatment of extracapsular fractures. In view of the interest attending the successful progress made in fractures of the neck of the femur, the extracapsular fractures have fallen somewhat into obscurity. They remain nevertheless extremely important problems, particularly in view of their frequency and of the disability so often due to inadequate reduction.

Fractures of the greater and lesser trochanters, and fracture dislocations at the hip, including the posterior and the central types, have received comparatively scant attention. This apparent negligence is due primarily to their relative infrequency, and secondarily, to the consummation of the time and energy devoted to femoral neck fractures.

It is obvious that the foregoing introduction merely touches on some of the highlights associated with the progress related to this important group of fractures.

The remainder of this section will be devoted to the classification, illustration, and a brief description of each fracture with special reference to diagnosis, treatment and prognosis.

#### CLASSIFICATION

1. Fractures of the upper end of the femur
  - A. Fractures of the femoral head
  - B. Fractures of the neck of the femur
    1. Subcapital
    2. Cervical
    3. Basilar
    4. Slipped femoral epiphysis
  - C. Trochanteric fractures
    1. Trochanter major

2. Trochanter minor
3. Intertrochanteric
4. Pertrochanteric
5. Subtrochanteric
2. Fracture dislocations at the hip joint
  - A. Central dislocation of the femoral head
    1. Pure central dislocations (fracture limited primarily to the acetabulum, its rim and wall)
    2. Central dislocations involving the rim, the floor, and the lateral wall of the pelvis (ischium valgum)
  - B. Posterior dislocation of the femoral head accompanied by fracture of the acetabular rim
  - C. Posterior dislocation of the acetabulum accompanied by fracture of the femoral head

#### DISCUSSION

1. Capital Fractures. (Figs. 1, 3, 4, and 5.)
  - A. Etiology. Direct violence applied to the head of the femur through the thigh with the thigh in the semiflexed and adducted position.
  - B. Types. (1) A fracture of the femoral head accompanied by a subcapital fracture (Fig. 5); (2) a fracture of the femoral head accompanied by posterior superior hip joint dislocation. (Fig. 4.)
  - C. Signs and Symptoms. (1) The thigh is adducted and flexed—the amount depending upon the degree of dislocation present. (2) Muscle spasm, pain, and crepitus are present at the hip joint. (3) Movement is restricted in all directions.
  - D. Diagnosis. It is suspected from the above signs and symptoms but is established only by the x-ray.
  - E. Differential Diagnosis. (1) Pos-

terior superior dislocation; (2) subcapital fracture; (3) fracture of the neck and trochanteric

Should the blood supply from this source prove inadequate, one might expect delayed union or more probably nonunion.

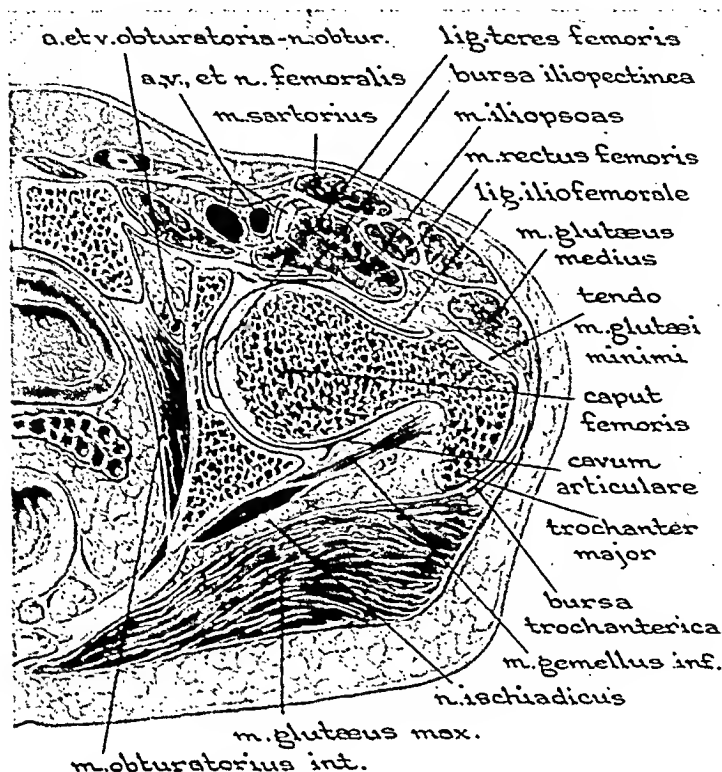


FIG. 1. A cross section of the human pelvis at the level of the femoral neck (Eycleshymer and Schoemaker).

areas. The diagnosis is established primarily by the x-ray.

F. Treatment. (1) Type 1 requires excision of the femoral head fragments and one of the reconstruction operations. (2) In Type 2 one may use: (a) reduction as if it were a posterior superior dislocation; (b) plaster immobilization for eight weeks; (c) non-weight-bearing walking caliper for six months; (d) physiotherapy.

G. Prognosis. In Type 1 very poor; in Type 2 good.

Figure 4A illustrates a three year end result in the case shown in Figure 4. Solid union and excellent hip joint movement are present.

Note. Capital fractures are intracapsular fractures. The circulation of one or more fragments may be dependent solely upon the ligamentum teres for blood supply.

## 2. Fractures of the Neck of the Femur.

### A. Subcapital (Figs. 1, 3, 5, and 6.)

1. Etiology. The mechanics of the fracture production is probably similar to that occurring in capital fractures. The thigh is in less adduction and the neck is literally sheared off the head at the border of the acetabular rim. (Fig. 6.) A capital fracture may occur in conjunction with the subcapital fracture. (Fig. 5.)

2. Physical Signs. The signs and symptoms are similar to those which are observed in cervical fractures. (See cervical fractures). The x-ray demonstrates a fracture of the femoral neck at the base of the head. The fracture line corresponds approximately to the

site of the former epiphyseal line.

3. Diagnosis. There are no clinical signs specific for this

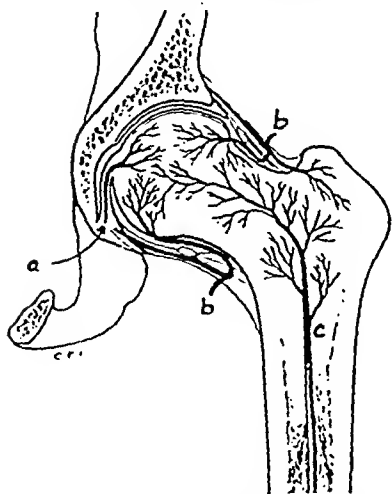


FIG. 2. Schematic drawing showing the circulation of the head and neck of the femur (Campbell). *a*, artery of the ligamentum teres. *b*, capsular arteries. *c*, nutrient artery.

fracture. The detection is dependent entirely upon the x-ray.

fractures with this modification—complete bed rest with weight and pulley traction for twelve weeks. Partial weight bearing—caliper and crutches—for six months. (See treatment of cervical fractures).

6. Prognosis. The prognosis is poor due to: (1) the circulation of the proximal fragment is dependent entirely upon the ligamentum teres for its blood supply. The blood supply of the ligamentum teres is inadequate in the majority of cases. (Fig. 2.) The subsequent displacement after excellent reduction is very apt to occur in view of the fact that the fracture line is constantly subject to a shearing stress. Accurate reduction is absolutely essential. Coxa vara must not be accepted. Coxa

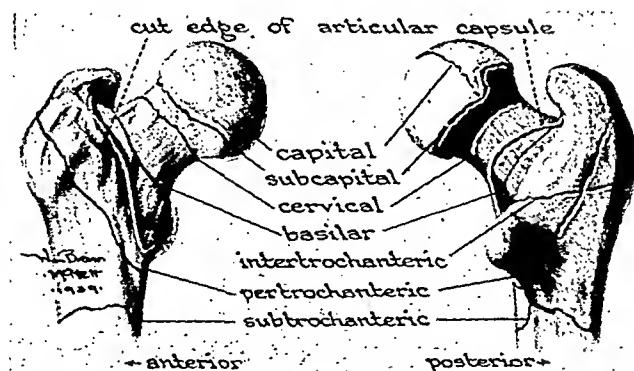


FIG. 3. An anterior posterior view of the proximal end of the femur. Note the various fracture planes and their relationship to the capsule attachment.

4. Differential Diagnosis. This fracture must be differentiated particularly from the cervical and capital fractures. (See prognosis). The distinction is determined radiographically.
5. Treatment. The treatment is similar to that of cervical

valga, though more favorable, diminishes the amount of fracture surface apposition. Internal fixation is essential to maintenance.

*Note.* It is extremely important that the subcapital fracture be not carelessly included in the cervical fracture group. It should be given special consideration in

view of the fact that it ranks first in non-union of all fractures of the femoral neck.

upon the amount of displacement present. The trochanter is above Nelaton's line.

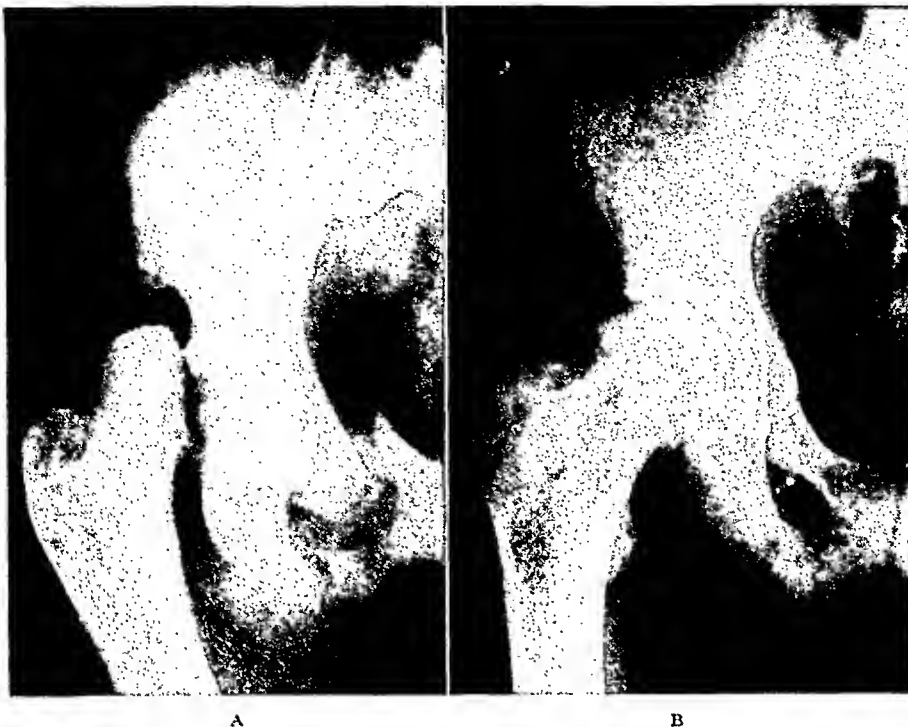


FIG. 4. A, a capital fracture. One-half of the femoral head remains in the acetabulum. The other half is dislocated and remains attached to the femoral neck. B, fracture healed.

#### B. Cervical (Figs. 1, 3, 7, and 8.)

1. Etiology. Cervical fractures are commonly known as fractures of the aged, and are most frequently seen in the fifth, sixth, seventh, and eighth decades of life. They are produced by indirect violence. The patient usually has a fall, striking on the posterolateral aspect of the hip. The thigh is flexed, adducted, and internally rotated. The force is spent largely on the trochanter and in the direction of internal rotation. The mechanism of the fracture is essentially one of internal torsion.
2. Physical Signs. The extremity is externally rotated (helpless eversion), slightly adducted, and various degrees of shortening are present, depending

Bryant's triangle is obliterated. Crepitus and muscle spasm are noted. Movement is restricted in all directions (pseudoparalysis). There is marked local tenderness over the anterior aspect of the hip joint, just lateral to the femoral artery. The patient is usually in moderate shock and generally complains of intense pain in the hip joint, sometimes referred to the knee.

3. Differential Diagnosis. Cervical fracture must be differentiated from the trochanteric and subcapital fractures. The x-ray is absolutely necessary for this distinction.
4. Diagnosis. The diagnosis is based primarily on the x-ray signs.
5. Treatment. Reduction—The x-ray clearly defines the frac-

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ture deformity. Simple stereo anteroposterior views are inadequate for this purpose.

usually employed for reduction. Both procedures are dependent primarily on the above principles. In the Whitman method

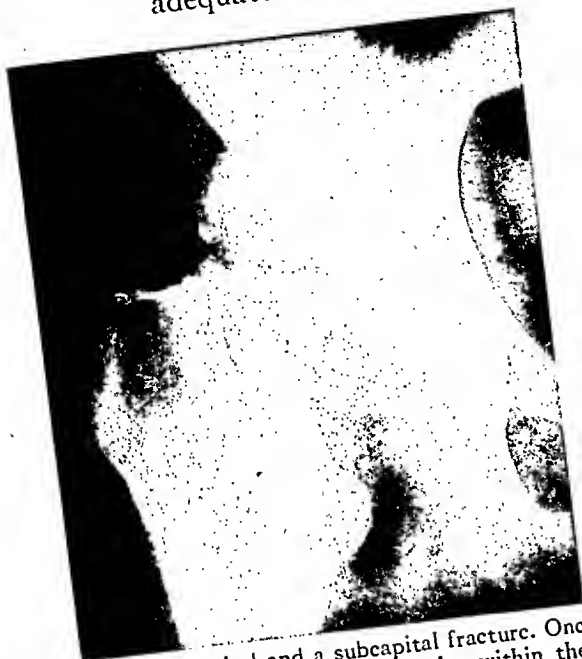


FIG. 5. A capital and a subcapital fracture. One half of the femoral head remains within the acetabulum while the other half is displaced superiorly. The neck is separated from the head fragments by a fracture through the subcapital area.



FIG. 6. A subcapital fracture.

The anteroposterior and the lateral views are essential to this determination. (Fig. 7.) The essentials of fracture deformity are: (a) shortening; (b) external rotation of the distal fragment; (c) anterior or posterior displacement of the distal fragment; and (d) coxa vara. Normally the neck and shaft form an angle of approximately 125 degrees. In cervical fractures this angle approximates 90 degrees or less.

To reduce the fracture one must eliminate the above deformity factors. The essentials to reduction are: (a) traction (b) internal rotation; and (c) abduction. These movements must be simultaneous, for one done independently tends to prevent the completion of the other two movements. The Leadbetter or the Whitman maneuver is

the correction is executed with the thigh in the horizontal position. Leadbetter performs the identical correction with the thigh and knee flexed 90 degrees. He contends that the joint structures are more relaxed in this position, thus facilitating reduction.

*Reduction Test.* There is but one reliable reduction test and this is the x-ray. After the reduction maneuvers have been executed, the corrected position is maintained by keeping the thigh abducted, internally rotated, and in moderate hyperextension. The "Y" ligament of Bigelow, according to Royal Whitman, is placed under extreme tension while the extremity is in this position, and this rugged, powerful ligament is thus capable of maintaining the fracture surfaces in apposition. The anteroposterior and lateral x-rays must then be repeated.

Leadbetter has described the heel and palm test (Leadbetter's sign) as a valuable means of determining a successful reduction. The test briefly is as follows: After his

reduction maneuver, the thigh is placed in abduction, internal rotation, and hyperextension to maintain reduction. The heel

of the normal side in the palm and does not maintain forced abduction, the extremity immediately rolls into external rotation. If



FIG. 7. A, anterior-posterior view of a cervical fracture. B, lateral view. C, the fracture reduced and fixated by the Smith-Petersen nail. A. P. view. D, lateral view.

on the fractured side is then allowed to rest on the palm of the hand. If the extremity rolls outward (externally rotates) reduction has failed. If, on the other hand, the extremity remains internally rotated, the reduction is complete.

*Note.* The writer is not in accord with the Leadbetter reduction sign for the following reason: Continuous abduction must be maintained even on the normal side in order to prevent the extremity from externally rotating. If one places the heel

sufficient abduction is maintained on the side of an unreduced fracture, the thigh will not externally rotate. The test, therefore, from the writer's viewpoint, is of questionable value.

*Fixation.* Internal fixation is maintained by means of the Smith-Petersen nail. Fixation may be obtained by nail, pins, wire, screws, autogenous bone graft, or other materials. The three-flanged nail of M. N. Smith-Petersen and the steel pin of Austin Moore are probably the most widely



used agents at the present time. Blind nailing or pinning has almost entirely supplanted the open reduction methods.

or properly placed wires or pins (Fig. 7c and d); (4) impaction of the fragments if there is the slightest evidence of distrac-



FIG. 8. A, a non-united cervical fracture. The neck of the femur has undergone absorption. The head is dead. Note especially the increased density of the head compared to the density of the surrounding bone. B, same fracture two years after a Brackett reconstruction operation.

Blind nailing is accomplished either by the wire guide, one of the numerous direction finders, or by means of the fluoroscope. The writer prefers the Smith-Petersen nail and employs the fluoroscope for its insertion. An incision only large enough to admit the nail is made at the base of the great trochanter.

The exact site is determined with fluoroscopic guidance. The nail is then directed through the central portion of the neck into the center of the head—with the aid of the fluoroscope. It is necessary repeatedly to check the course of the nail in the anteroposterior and the lateral views. Should visualization become doubtful, anteroposterior and lateral x-rays are taken. In case the alignment is unsatisfactory, the nail is retracted and reinserted. Regardless of the method of nailing, or the material used, the following essentials are necessary to adequate internal fixation: (1) pre-reduction visualization with anteroposterior and lateral x-rays (Fig. 7A and B); (2) accurate reduction; (3) a centrally positioned nail

tion; and (5) adequate anteroposterior and lateral post-reduction films (Fig. 7c and d).

*Note.* Adequate anesthesia, preferably general, eliminates one of the principal reduction obstacles. Complete relaxation is essential to the reduction of any fracture. Many fracture methods have been devised and thought necessary because of the violation of this principle. Avertin anesthesia supplemented by nitrous oxide has proved satisfactory to the writer.

*Post-Reduction Care.* (1) Bed rest with weight and pulley for eight weeks. (2) Anteroposterior and lateral x-rays at the end of six weeks. (3) Crutches with partial weight bearing for six months. (4) Anteroposterior and lateral x-rays at the end of six months.

*Note.* Physiotherapy during the entire protection period directed principally to the maintenance of proper muscle tone about the hip and knee is necessary.

*Prognosis.* The prognosis is dependent upon the following factors: (1) accurate reduction; (2) adequate fixation; (3) ade-

quate after-care; and (4) blood supply to the proximal fragment.

Since the establishment of internal fixa-

still a problem of controversy. The femoral head and neck receive their blood supply from four sources (Fig. 2): (1) nutrient



FIG. 9. A, a basilar fracture. The fracture line extends partly into the great trochanter. Hence, it is not a true basilar fracture. B, anteroposterior view of the same fracture shows the fracture confined primarily to the base of the neck. C, anteroposterior view of the nailed and healed fracture. D, lateral view.

tion by Smith-Petersen in 1925, the percentage of osseous union in cervical fractures of the femur has constantly risen. A successful result may be expected in approximately 75 per cent of the cases of cervical fractures according to reports of the majority of fracture clinics. The blood supply of the proximal fragment is

artery; (2) superior capsular vessels; (3) inferior capsular vessels; and (4) ligamentum teres.

In subcapital and high cervical fractures in which there has been extensive displacement the proximal fragment may depend entirely upon the ligamentum teres for its blood supply. The capsular vessels enter

the neck at its base and in the above types the blood supply to the proximal fragment is cut off. The ligamentum teres may afford



FIG. 10. Anteroposterior view of a slipped femoral epiphysis.

an inadequate blood supply. The proximal fragment may therefore die. The death of this fragment is referred to as "the aseptic necrosis of Phemister." (Fig. 8A.) Non-union occurs. In these cases one of the reconstruction operations, as that of Brackett, Whitman, Albee, Colonna, etc., may be necessary to eliminate pain and to restore some degree of usefulness to the hip. The writer prefers the Brackett operation. (Fig. 8B.) Non-union may also occur here, in fact does frequently occur, because of improper reduction or improper fixation. In many of these cases the head remains viable. The Albee bone graft is the method of preference in this group.

The prognosis in the cervical fracture has a far brighter outlook than ever before. The Whitman abduction cast method has ap-

parently served its usefulness and has been replaced by internal fixation. The convalescent period is more comfortable and the mortality rate of the cervical fracture has been materially lowered. Smith-Petersen and others have stressed the importance of a two year follow-up before coming to a final decision regarding bony union. This may greatly reduce the present optimism. But, even so, in view of the foregoing statements relative to the advantages of internal fixation, the method will have earned its right to exist.

*Note.* Recognition of the "dead head" is determined by the x-ray—principally. (Fig. 8A.) It is characterized by its intense whiteness in comparison with the surrounding bony structures. The increased density is thought to be due to a total loss of blood supply. Demineralization due to disuse occurs in all bony structures, but can occur only providing an intact blood supply is maintained.

*Caution:* Non-union due to poor reduction, poor fixation, and in general poor treatment is too frequently attributed to the dead head. For that reason one must take care not to overemphasize this interesting but very infrequent complication.

#### C. Basilar.

The previous fractures have been intracapsular. The basilar fracture has the unique distinction of being intra- and extracapsular. (Fig. 3.)

*Etiology.* Indirect force similar to that producing trochanteric fractures.

*Physical Signs.* Similar to cervical fractures.

*Differential Diagnosis.* X-ray.

*Diagnosis.* X-ray.

*Treatment.* Identical with that for cervical fractures—internal fixation.

*Prognosis.* Excellent.

*Note.* The proximal fragment is assured of a blood supply. The large diameter of the cervical base affords broad contact.

#### D. Slipped Epiphysis.

The slipped epiphysis belongs probably to the pathologic fractures of the neck of the femur. It occurs more frequently in

females than in males and is usually seen between the ages of 12 and 18 years.

Etiology. The slipping progresses rather

and has cast grave doubt upon this explanation.

Clinical Signs. The obese adolescent



FIG. 11. A, fracture of the trochanter minor. B, healed fracture. (Courtesy of J. T. Nicholson.)

slowly until some comparatively minor injury produces a sudden and marked displacement. The displacement or slipping

girl (Fröhlich type) begins to limp slightly. The hip gradually becomes stiff and the extremity becomes shortened. Pain is usu-

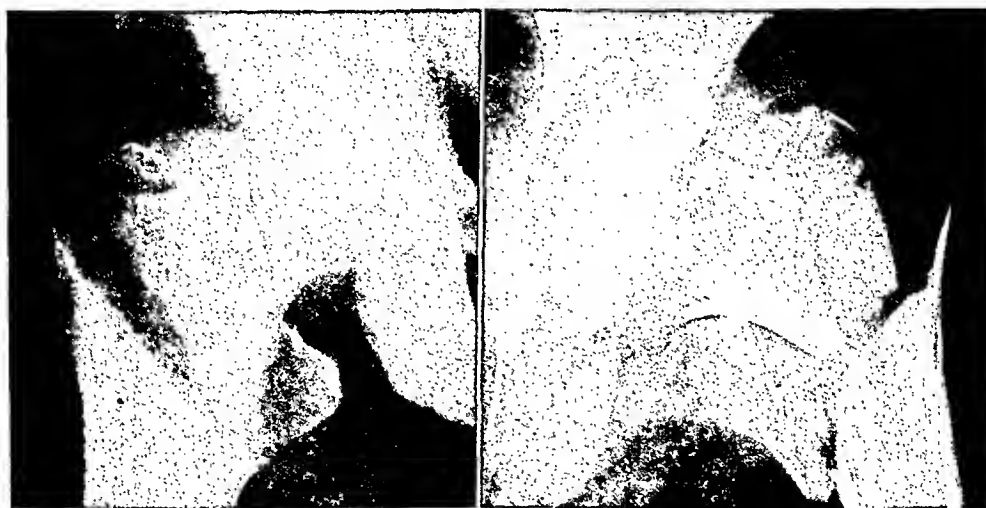


FIG. 12. A, pertrochanteric fracture—simple. B, pertrochanteric fracture—comminuted.

occurs at the epiphyseal line, and the location corresponds to the subcapital fracture seen in the adult. The frequency with which the slipped epiphysis is seen in the hypopituitary type suggests an endocrine basis for its occurrence. The failure of the early cases to respond to endocrine therapy has been very discouraging

ally present at the hip but very often present only at the knee joint (referred pain). If the joint movement is determined at this period, there is found a loss of abduction, internal rotation and extension. A slight misstep or trivial fall suddenly produces a sharp pain at the hip joint. The x-ray shows the femoral head in the acetab-

## Moore—Fracture of Femur

ulum. The neck is displaced upwards. The distal fragment is in marked external rotation, and coxa vara is noticeable.

In the pre-slipped period it is often confused with coxa plana and epiphysitis of low grade inflammatory origin. Prolonged

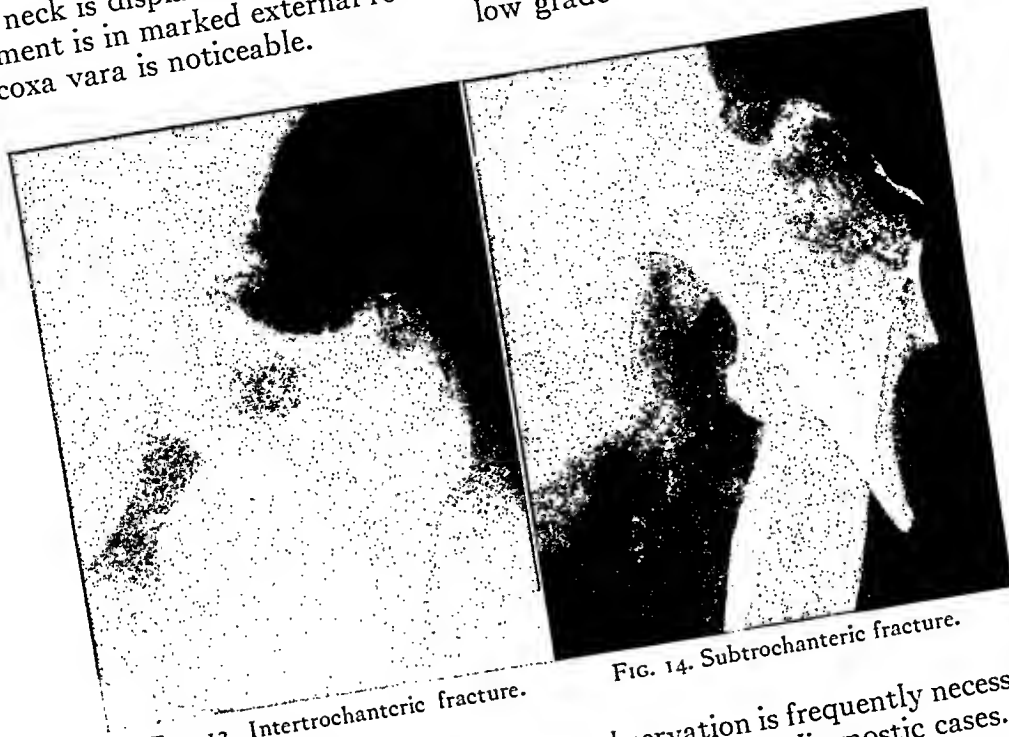


FIG. 13. Intertrochanteric fracture.

FIG. 14. Subtrochanteric fracture.

**Diagnosis.** The diagnosis is suspected in view of the clinical signs and is corroborated by the x-ray. The lesion is very often bilateral. The stages of slipped epiphysis are recognized by:

1. Pre-slipped period. The epiphyseal line is widened and irregular. The adjacent neck is widened, particularly the inferior surface. This latter projects below the head and looks somewhat like a chin. The deformity is referred to as "chinning." At this stage one may notice a slight bending of the neck in the antero-posterior view. This bending occurs at the junction of the neck and epiphyseal line (metaphyseal area). In the lateral view a slight but very definite anterior bending may be present.

2. Slipped period. Described under the physical signs.

**Differential Diagnosis.** This condition must be distinguished primarily from subcapital fracture. The x-ray and clinical pictures make the diagnosis relatively easy.

observation is frequently necessary in these more difficult diagnostic cases.

#### Treatment.

1. Pre-slipped period. Internal fixation with the Smith-Petersen nail offers the most certain means of arresting the process.
2. Slipped period. One may divide the cases into two groups. (a) Fresh slipped—reduction is accomplished similar to that in cervical fractures but with utmost gentleness, followed by immediate internal fixation; (b) Older cases with malunion—subtrochanteric osteotomy offers the most helpful outlook.

**Prognosis.** Excellent in the pre-slipped period; good in the fresh slipped group and rather poor in the malunited group. (Fig. 10.)

#### 3. Trochanteric Fractures.

A. *Trochanter Major.* This is a very rare fracture. It is produced by direct force.

**Physical Signs.** The thigh is adducted. Active abduction of

the hip is lost. External rotation and extension (active) are greatly diminished. Marked

terminated principally by the x-ray. The trochanter fragment is displaced upward and back-

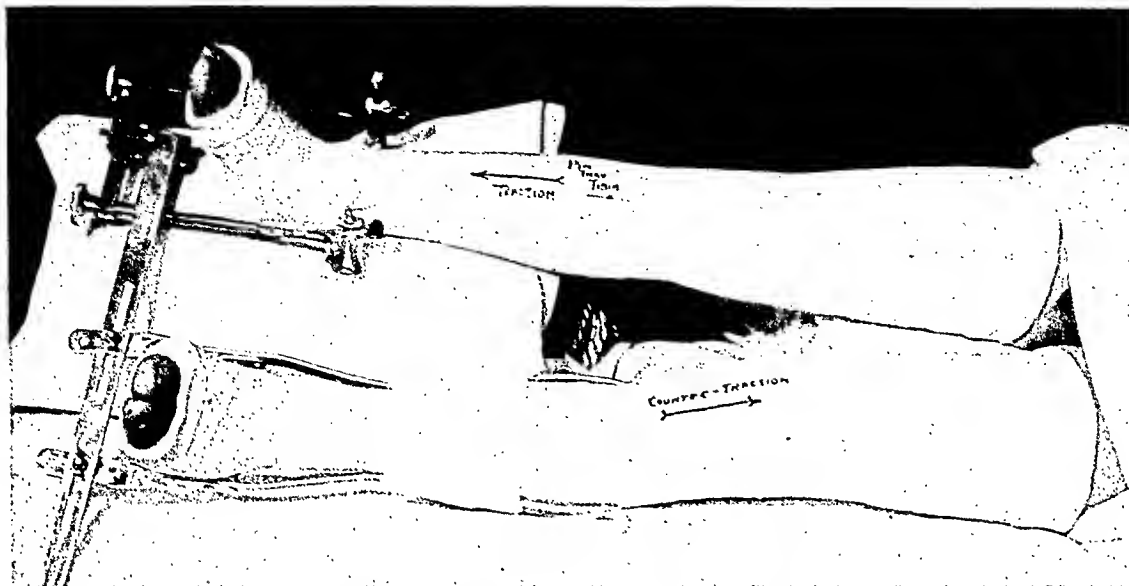


FIG. 15. Well leg traction—Roger Anderson.

local tenderness over the lateral aspect of the hip is present. Crepitus may be noticed upon palpation of the greater tro-

wards due to the pull of the abductors and the short external rotators.

Differential Diagnosis. A



FIG. 16. A, central dislocation of the femoral head. The entire wall of the pelvis is carried in with the dislocation (ischium valgum). B, reduction of the central dislocation.

chanter. A mass can frequently be felt. Extensive ecchymosis is seen over the lateral and posterior area of the hip.

Diagnosis. Diagnosis is de-

major fracture of the greater trochanter is readily recognized. Incomplete or avulsion of the muscle insertion offers the greatest difficulty. The latter is

easily mistaken for a calcified greater trochanter bursitis.

Treatment. Wide abduction

is a very unusual fracture (Fig. 11). The fracture is produced by indirect force and is due to

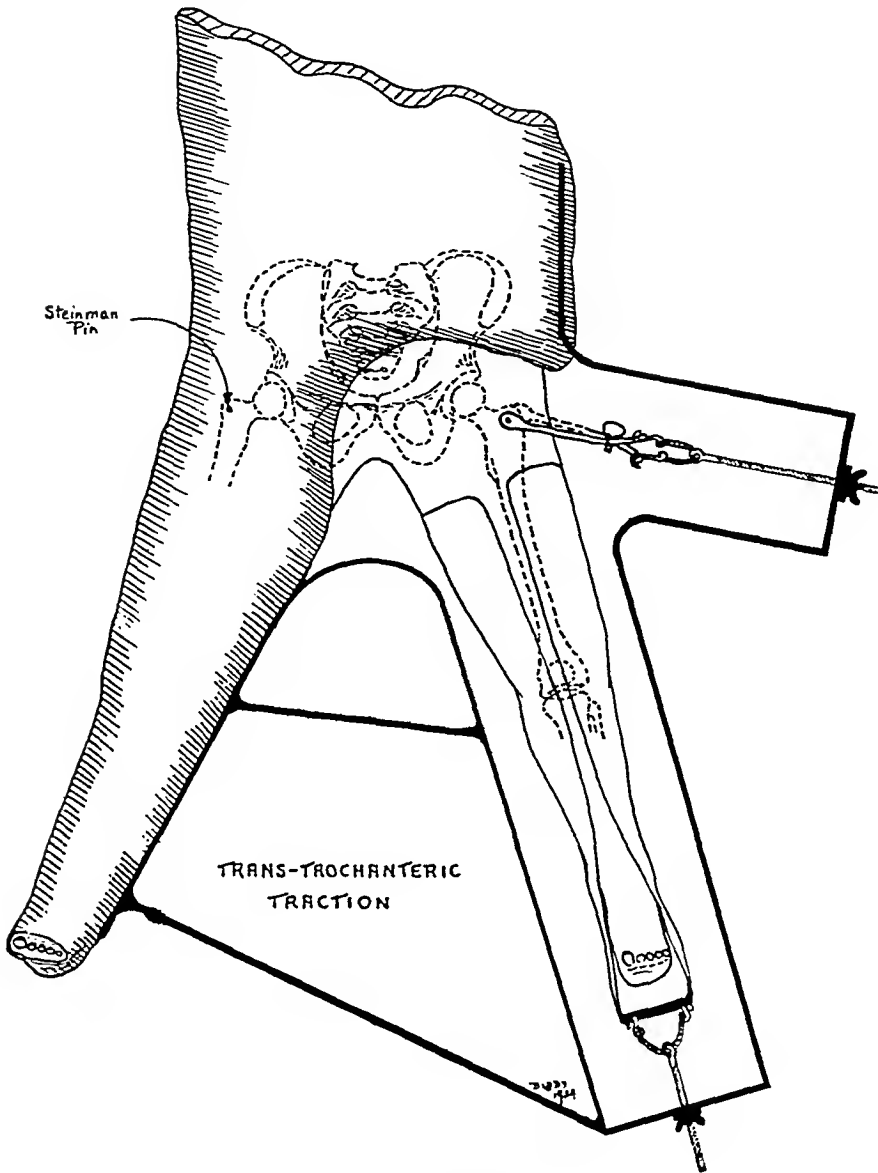


FIG. 17. Transtrochanteric traction.

and external rotation may adequately approximate the fragment. Should this manipulation fail, an open reduction must be performed, with fixation in plaster of Paris spica for six weeks.

Prognosis. Excellent.

B. *Lesser Trochanter*. This, as in the case of the greater trochanter,

violent contraction of the iliopsoas tendon. It is usually seen in adolescents. (There is probably an underlying osteochondritis similar to Legg-Perthes, Osgood-Schlatter's disease, etc.)

Physical Signs. Active hip flexion is restricted and painful. Pain is intense at the site of the



lesser trochanter on passive hyperextension and internal rotation. The thigh is usually flexed, abducted, and externally rotated. There is deep tenderness over the lesser trochanter area.

Diagnosis. Determined by x-ray.

Differential Diagnosis. Complete separation of the lesser trochanter is easily recognized. Incomplete separation must be differentiated from iliopsoas bursitis.

Treatment. The thigh is immobilized in plaster of Paris spica. The thigh is flexed and externally rotated. It is held for six weeks.

Prognosis. Excellent. (Fig. 11B.)

C. *Intertrochanteric, Pertrochanteric, and Subtrochanteric.* (Figs. 12A and B, 13, 14, and 15.) These fractures are also known as fractures of the aged.

Etiology. Direct force. The patient falls in such a manner that the entire force is applied directly to the greater trochanter. Were the trochanteric area to remain intact, a central dislocation would probably occur.

Physical Signs and Symptoms. Similar to those of cervical fractures except that the general shock is more pronounced.

Diagnosis. Established by the x-ray.

Treatment. Application of the well leg traction.

*Note.* The above fractures may be simple or comminuted. Displacement may be mild or pronounced. Union seems inevitable in this group. Malunion, due to inadequate reduction and immobilization is common. Traction and mild internal rotation are essential to reduction. The well leg traction principle as suggested by Hoke,

Jones, Steindler, and others, offers the most consistent success. Elimination of a body cast permits the patient to sit up and have early use of the wheel chair. Fixation is indicated for a period of eight weeks. Physiotherapy to restore the ankle, knee, and hip motion is usually necessary for six months.

#### 4. *Fracture Dislocations of the Hip Joint.*

A. *Central Dislocation of the Femoral Head.* Pure central dislocation of the femoral head with fracture limited primarily to the acetabular wall is a comparatively infrequent injury.

Etiology. Indirect force. The fracture is produced usually by great violence—the force being applied squarely against the greater trochanter in the direction of the line of the femoral neck and head. The head is driven through the acetabular wall and usually projects within the pelvis.

Physical Signs. Intense pain at the site of the hip joint. The patient is usually in rather severe shock. There is a slight shortening and a very marked restriction in hip movement with the exception of flexion. On rectal examination, the head of the femur or the bulging acetabular wall can be felt through the rectal wall. The greater trochanter is less prominent, and in some instances is located with great difficulty due to its central displacement.

Diagnosis. X-ray shows a characteristic dislocation of the femoral head.

Treatment. Manipulation—consists of forced abduction combined with lateral traction. This usually restores the head to its normal position. The fragments in the acetabulum can

sometimes be moulded back into place through the rectum. Fixation in a plaster cast is

most suitable for the management of this type of fracture. Fixation for twelve weeks is



FIG. 18. Posterior dislocation. Note the rim fracture of the acetabulum.

sufficient very often—fixation to be held for ten weeks. Should redislocation occur, then transtrochanteric traction is advisable. (Fig. 17.) Partial weight bearing with crutches is permitted for six months.

A central dislocation of the femoral head may occur and is complicated by a collapse of the entire lateral pelvic wall (ischium valgum). (Fig. 16.)

**Physical Signs.** Similar to those of pure central dislocation except for the additional tendency to internal injury, injury to the sciatic nerve, and pronounced shock.

**Diagnosis.** Determined by the physical signs and the x-ray.

**Treatment.** Transtrochanteric traction (Fig. 17) seems

necessary and partial weight bearing with crutches for six months is advisable.

**Prognosis.** Good for a useful hip in the majority of cases providing reduction is adequate.

#### B. Posterior Dislocation of the Femoral head Accompanied by Fracture of the Acetabular Rim.

**Etiology.** Violent force applied to the thigh in the direction of the femoral head. The thigh is adducted and flexed—similar to the position predisposing to capital, subcapital fractures and posterior-superior dislocation of the hip. The posterior-superior rim of the acetabulum is carried away with the dislocating head.

**Clinical Signs.** Similar to those of posterior-superior dis-

location of the hip except for the presence of crepitus.

**Diagnosis.** The diagnosis is established by x-ray.

**Differential Diagnosis.** This injury must be distinguished from pure posterior-superior dislocation of the hip, capital and subcapital fractures.

**Treatment.** Manipulation—same maneuver as employed in reduction of the posterior superior dislocation; namely, traction on the thigh with the hip flexed adducted. Fixation can usually be obtained by encasing the abducted and externally rotated lower extremity in a plaster of Paris spica of the hip. Should the acetabular rim fail to become replaced an open reduction with pegging of the loose fragment is positively essential.

**Prognosis.** Depends entirely upon the success and maintenance of reduction.

#### CONCLUSION

As presented in the introduction, fractures of the upper end of the femur, including fracture dislocations at the hip joint, form one of the most difficult of all fracture problems. The methods referred to in the preceding description are those found, by elimination, to be the most useful to the writer. Most of them are in common usage. In closing, it is extremely important to call attention to the fact that fractures involving the neck, the head and the acetabulum frequently bring about delayed changes in the hip joint after a few years. Arthritis, disintegration of the femoral head and the acetabulum are by no means unheard of sequelae. These complications should always be kept in mind before pronouncing a final judgment in regards to complete repair.

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THE proteins of milk and eggs contain the most complete supply of amino acids. Meats come next, with kidneys and liver better than the muscle meats.

# TREATMENT OF FRACTURES OF THE CARPAL END OF THE RADIUS BY TRACTION

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FRACTURES of the carpal end of the radius in adults may be regarded as unsatisfactory fractures to treat. Rarely

side. This deformity occurred more often in the comminuted type of fracture and in middle aged and elderly women who frac-

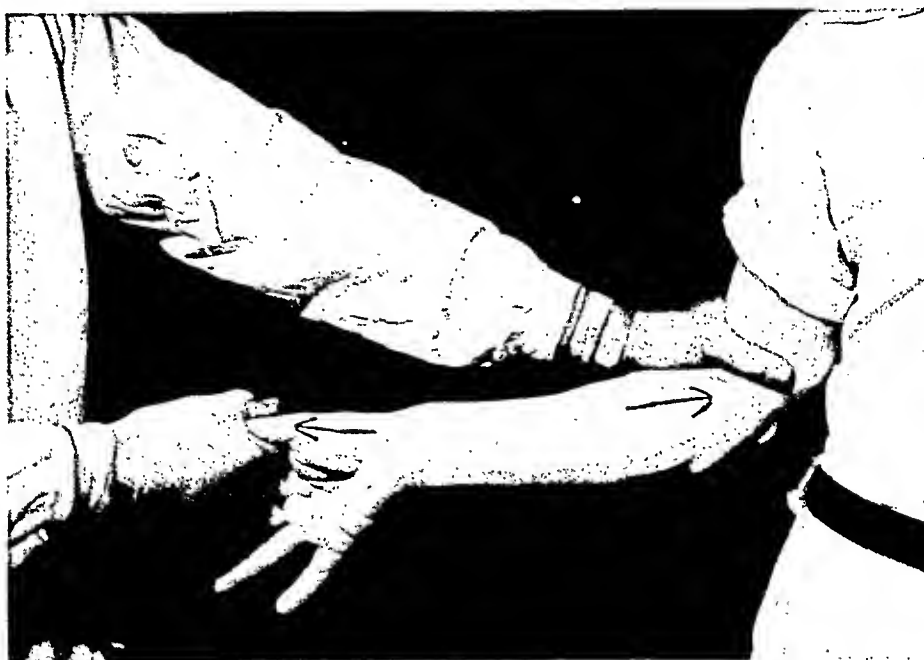


FIG. 1. How we would expect to hold the position after the reduction of a fracture of the lower end of the radius. Accomplished by the use of the constant traction shown in Figure 3.

is the end result satisfactory to both the patient and the attending surgeon. Slight deformities in this area receive undue notice on account of the ease of comparing it with the opposite or normal wrist and the difficulty of constantly concealing it from the observation of critical companions. Platt<sup>1</sup> quotes Grasby and Trick as follows: "After an examination of fifty cases treated at Guy's Hospital . . . in a Colles fracture with displacement the result after two years is invariably unsatisfactory."

The writer has seen what he regarded as an excellent reduction of a fracture in this area gradually assume the typical deformity of the excessively prominent ulna and the shifting of the hand toward the radial

tured their wrists in the area associated with the name of Colles. The use of the Roentgen ray places the site of fracture closer to the lower end of the radius than Colles described it in his report in the *Edinburgh Medical Journal* in 1814.<sup>2</sup> For the purpose of this paper I will confine it to the treatment of fractures of the lower end of the radius with or without an associated fracture of the styloid process of the ulna.

A very thorough search of the literature will show that few changes have taken place in the treatment of this fracture since Colles' time, with the exception of the use of anesthesia and the use of plaster of Paris material in splinting. One observer<sup>3</sup> has found in a mummy exhumed in Egypt the

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fracture with splints intact, showing anterior and posterior wooden supports and resembling splints used today in all parts of the world.

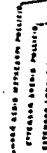


FIG. 2. A diagram from Gray's Anatomy showing the strong tendons crossing the fracture line in the Colles' type of fracture. The constant pull on the lower fragment, if unopposed, causes the shortening and consequent deformity of the radius.

A great improvement has been noted in the treatment of most of the other fractures of bones of the body during the last several decades. It does not seem that the end results in the Colles type of fracture have shared this general improvement. The honor or dishonor of the title of "the unsolved fracture,"<sup>4</sup> was applied some years ago to the fracture of the neck of the femur, but the improved method of treatment by nailing seems to be solving the difficulties associated with this fracture. The treatment of the Colles type of fracture remained in my hands unsatisfactory. As in fractures of the neck of the femur a gradual melting away of the visible bone substance seemed to take place. Research

carried out in many quarters on the subject has not helped the surgeon materially nor has it shown the exact cause of this absorption. Strangely, enough, although non-union is seen frequently in fractures of the neck of the femur it is rarely seen in fractures of the Colles type.

When a fracture of the radius is associated with a fracture of the shaft of the ulna at the same level in the wrist, the deformity does not occur, as both bones shorten equally and slightly in the process of healing. The deformity seems to take place when the radius alone or when the styloid process and not the shaft of the ulna is involved.

In the writer's experience, the usual manner of splinting did not prevent shortening of the radius from developing. After many humiliating experiences, a method of splinting with traction has been devised which may be used practically and without complicated apparatus in almost every fracture in this area in which shortening of the radius alone is apt to occur.

DESCRIPTION OF METHOD

DESCRIPTION OF METHOD

First of all the treatment of this fracture must be taken seriously and deliberately. The kitchen table or the family davenport has no place in the method to be described. If the patient has recently taken food, a reasonable length of time must be allowed for it to pass out of the stomach. In proper surroundings and with adequate assistance, the patient is anesthetized by the method suitable to the individual patient. The fracture is reduced *accurately* and *completely* by one of the many methods. The writer uses a combination of many methods, making sure that any deforming impaction is broken up. The completeness of the reduction is checked by x-ray.

The skin at the base of the thumb and the first metacarpal is then painted with compound tincture of benzoin. A loop of double thickness adhesive, or moleskin  $1\frac{1}{2}$  to 2 inches wide is wrapped about the base of the thumb, the first metacarpal and the index finger, as shown in Figure 6. The

ends of the adhesive loop, overlap or cross in such a manner that it is capable of sustaining a reasonable pull. A second strip

fracture line. (Fig. 2.) The tension maintained in this manner carries the carpus to the ulnar side and prevents dislocation

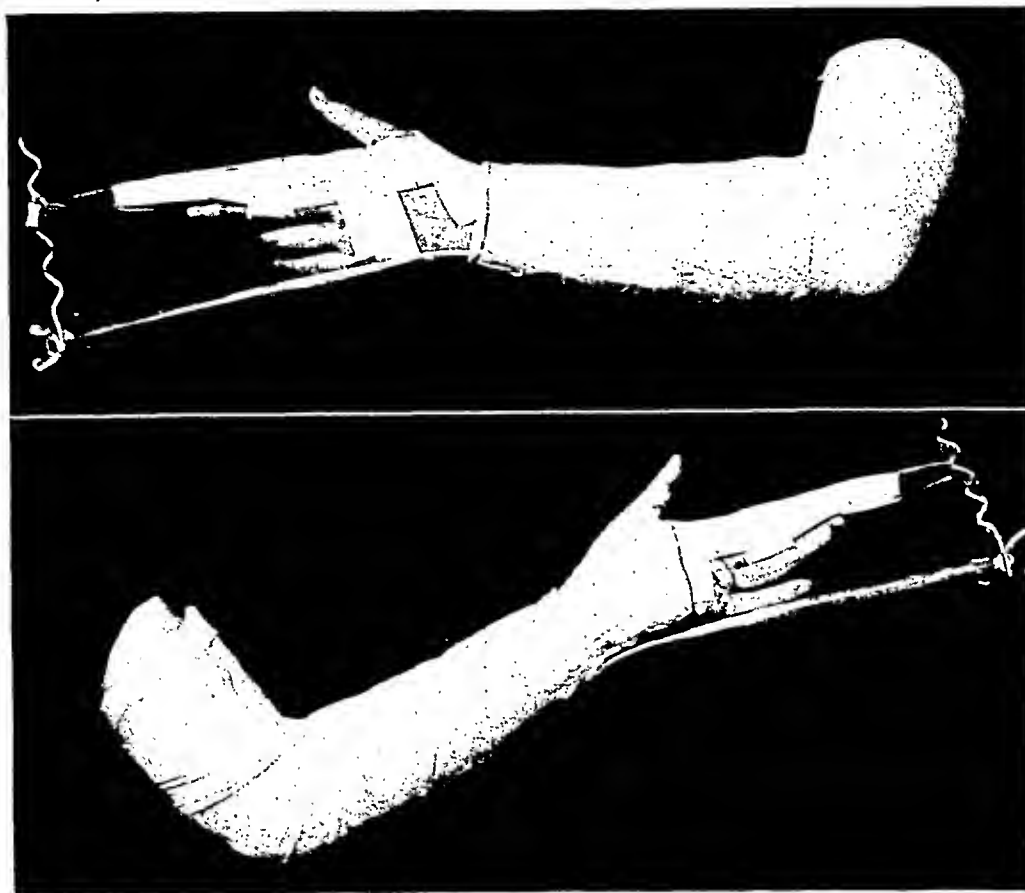


FIG. 3. Constant tension on the thumb and index fingers to counteract the deforming influences of the intact tendons.

applied transversely prevents slipping. Stockinette is placed as high up as the mid-humerus and a strip of felt  $\frac{1}{2}$  inch in thickness is attached to the front of the upper arm, passing downward past the crease of the elbow. A light and practically unpadded plaster of Paris cast is applied from the palm of the hand to the mid-humeral region. Incorporated in the cast is a traction apparatus or a banjo type of splint made of strong wire or a light metal, such as duralumin. A rubber strip or a spring (Fig. 4) connects the adhesive loop to the metal part of the splint<sup>1</sup> and maintains reduction until such time as the compressed area on the back of the radius has become filled in with new bone or organized tissue of sufficient stability to withstand and counteract the pull of the strong muscles and tendons crossing the

taking place at the inferior radio-ulnar joint. The hand is placed in slight supination, or midway between pronation and supination. In compound fractures, double pins may be used (King<sup>5</sup>). If the skin is intact the writer finds that pins or wires are unnecessary.

It is fundamental that the fracture be thoroughly reduced before applying this method of splinting. This is not to be regarded as a method of reduction, but as a method of maintaining reduction. Successful immobilization of "the joint above and the joint below the fracture line" is achieved. Frequent examination with fluoroscope or film is possible. The lower fragment remains under our control and minor adjustments may be carried out easily.

In the average patient a smaller cast may be applied and the traction apparatus



removed after the twenty-first day, but if there has been much comminution it should be left intact for four or five weeks. A pistol

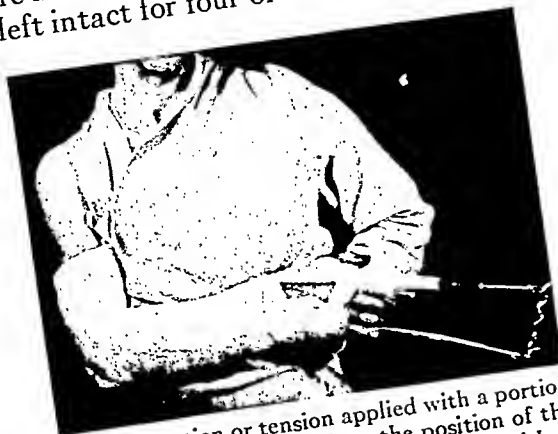


FIG. 4. Traction or tension applied with a portion of the cast cut out to show the position of the adhesive strips. Tension maintained with a spring register.

grip or a sugar tong-shaped splint may be used for comfort for three more weeks.

The errors I have observed in this method of treatment have been due to too



FIG. 5. The wrong way to apply this method. The plaster of Paris should include the elbow joint to prevent supination and pronation.

much tension, which is apt to pull the strips loose; or in too little tension which may be valueless. The use of a lower arm cast alone is incorrect also. I have found that the equivalent of the use of 3 or 4 pounds of weight will overcome the deforming influences.

It is difficult to compare various methods with regard to the amount of stiffness of the fingers and wrist which follows, since the stiffness varies in degree according to the individual. There seems to be some rela-

tionship between the accuracy of the reduction and the restoration of normal mechanics at the wrist joint and the amount of stiffness and arthritic manifestations which develops. Much of the stiffness is due to injury to the tendons and tendon sheaths and hemorrhage or effusion into them. The method of treatment here proposed, by maintaining the tissues at their maximum length in the position of function, seems to lessen the amount of residual stiffness.

After using or supervising the use of this method in over eighty instances, I have seen shortening of the radius approaching a degree which could be described as unsatisfactory in only five.

#### SUMMARY

1. Deformity may be prevented from developing in a perfectly reduced fracture of the Colles type or in the comminuted

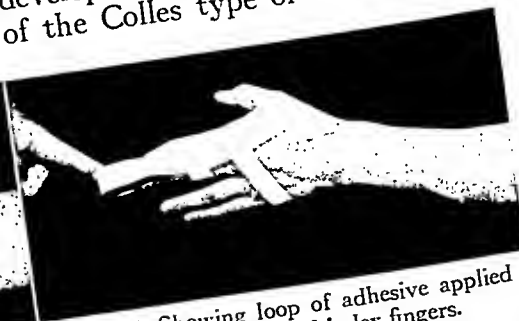


FIG. 6. Showing loop of adhesive applied to the thumb and index fingers.

fracture of the carpal end of the radius by continuous traction or tension for at least three weeks.

2. Adhesive strips applied to the radial half of the hand and attached to a splint buried in a cast which extends to the upper arm will accomplish this.

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# DASHBOARD FRACTURES OF THE PATELLA\*

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**D**URING the past thirty years we have witnessed the progress of the automobile through its progressive stages of development until it now plays a major rôle in the daily life of every one of us. Keeping pace with this mechanical advance we have also seen a steady increase in the frequency and severity of highway accidents. The orthopedic and traumatic surgeon has been confronted with a variety of bizarre and unusual injuries, certain of which are becoming recognized as typical automobile injuries because of the frequency of their occurrence in this connection.

A severely comminuted fracture of a portion of the patella is often the result of automobile accidents in which, due to the shock of collision or quick stopping, the victim is thrown forward and the tensed knee-cap strikes forcibly against the dashboard or other projection of the interior of the car. In a review of forty-three consecutive cases of fractured patella treated in the hospitals of Lincoln, Nebraska, twenty-nine, or 67½ per cent, were the result of automobile accidents. Three of these were automobile-pedestrian accidents while twenty-six, or 60 per cent, were definitely dashboard fractures. The severity of these dashboard fractures is indicated by the fact that nineteen of these twenty-six cases required open operative treatment. A careful study of statistical reports on fractures of the knee-cap, published from fifteen to twenty-five years ago,<sup>7</sup> would indicate that these severely comminuted fractures are occurring much more frequently at the present time, and it is evident that automobile injuries are largely responsible for this increase.

Due to the low osteogenic properties of the patella and the prolonged disability resulting from so-called conservative treatment, open operation and fixation has become the method of choice in the treatment of fractures presenting any considerable displacement.<sup>1,5,6,8</sup> This procedure has, in the hands of competent men, resulted in a high percentage of satisfactory results, and seems to be especially effective in transverse fractures where accurate reduction and fixation can be obtained. However, in cases presenting any considerable comminution the problem of reduction and fixation is extremely difficult, and in many instances accurate reduction cannot be maintained. In these cases bony union is delayed; disability is prolonged; atrophic changes occur; and the hope of obtaining a good functional result is definitely less than in the simple transverse fractures. Even when bony union has occurred in such a case, the roughening and irregularity of the articular surface of the bone predisposes to the occurrence of arthritic changes in the knee joint.

These difficulties occurring in severe fractures of the knee-cap have been recognized since the open operative method of treatment became practicable. Heineck,<sup>7</sup> in 1909, in reviewing 1,100 cases of fractured patella collected from the literature, found five cases reported in which complete excision of the patella had been done because of severe fracture, and in which satisfactory functional results were obtained. A number of cases were also reported in which a loose fragment had been removed. Thomson,<sup>9</sup> in 1934, called attention to the good result following complete excision of comminuted fragments in cer-

\* From the Orthopedic Clinic of J. E. M. Thomson and C. F. Ferciot, Lincoln, Nebraska.

tain instances where either the upper or lower pole of the patella was comminuted, following which the tendinous apparatus

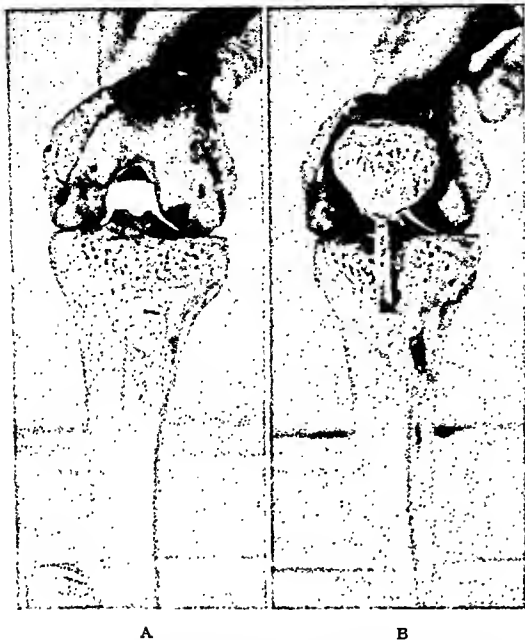


FIG. 1. A, note the extensive articular cartilage exposed when the knee is flexed. B, the patella acts as a bony pad protecting the articular surface.

was sutured directly to the remaining fragment. Henderson, in discussing patellar fractures in 1935,<sup>4</sup> stated that "When the lower fragment is very small it can be

TABLE I

Mode of Injury	Injured		Requiring Open Operation	
	No.	Per Cent	No.	Per Cent
Auto accidents.....	29	67.5	20	70
Dashboard fractures.....	26	60	19	73
Falls.....	14	32.5	8	57

removed entirely and not be missed." Blodgett and Fairchild,<sup>2</sup> in 1936, reported eight cases of total excision of the patella for acute fracture with satisfactory results. The younger patients were able to return to heavy work after three months. They also treated nine cases by excision

of fragments at the upper pole, and three cases by excision of fragments at the lower pole. No tendency of the patella to regenerate was found in any case. Brooke,<sup>3</sup> in 1937, reported thirty cases in which the patella had been completely excised for acute fracture. Full functional recovery was reported in all cases with a decided shortening in the period of expected disability.

There are relatively few references in the literature discussing the function of the

TABLE II  
TABLE OF END RESULTS OF CASES FOLLOWED

Method of Treatment	Total Number Treated	Good Results	Fair Results	Comminuted	Average Weeks Disability
Open fixation of fragments	6	4	2	2	17.65
External fixation only.....	6	6	0	0	10.65
Excision of fragments and suture.....	8	8	0	8	10.75
Totals.....	20	18	2	10	12.9

knee-cap to any length, the general consensus of opinion seeming to be that it is just another one of those sesamoid bones. Some have felt that it improved the mechanical advantage of the quadriceps force in certain positions, and further, that it added to the stability of the knee joint in the extended position. More recently, however, its function has been the subject of careful investigation, and Brooke<sup>3</sup> reports that its complete removal does not weaken the knee joint, but rather adds somewhat to the smoothness and celerity of motion response. His experimental work appears conclusive that it adds little to the mechanical advantage of the knee joint, and clinical reports of function following removal would seem to bear out his impression that the patella is a morphologic remnant which serves no important function.

After reviewing this series of cases, however, in which severe injury to the knee-cap was so common, the writer is impressed with the thought that the function of the patella in protecting the extensive articular cartilage of the lower end of the femur from

direct trauma deserves, perhaps, more consideration than it has been accorded. Projecting forward as it does in the inter-

lar surface of the femur would be exposed to the insult of repeated injury. The fact that this bone exhibits extremely low

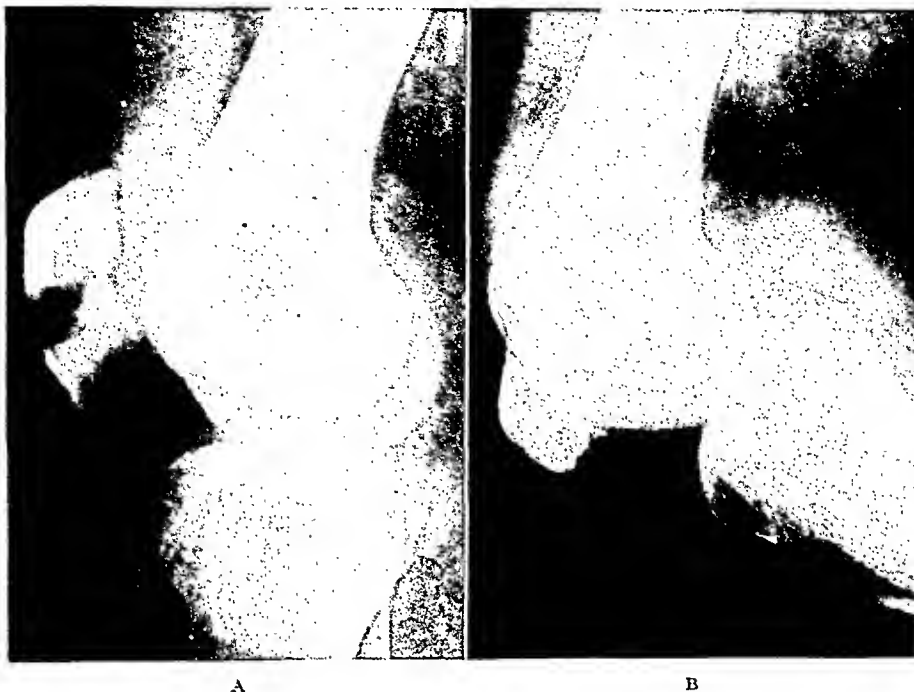


FIG. 2. A, dashboard fractures with some comminution. B, note position of remaining fragment two years later. It affords adequate protection to the knee joint.

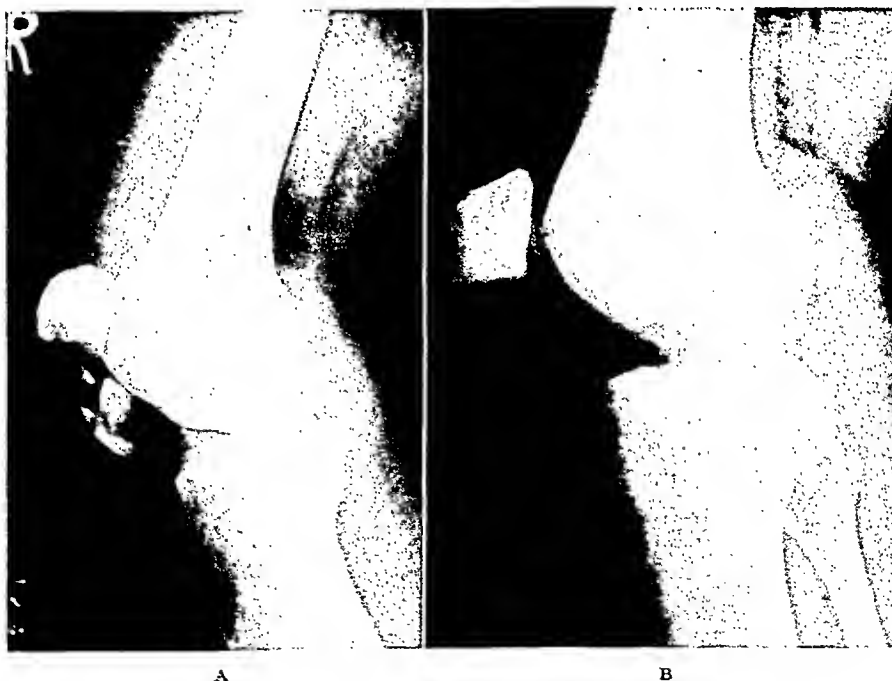


FIG. 3. A, compound comminuted fracture resulting from a fall. B, appearance one and one-half years after excision and repair.

condylar space, the patella forms an excellent buffer mechanism for the knee joint, particularly in the flexed position. Without its protection, a large portion of the articu-

reparative powers lends further credence to the impression that its function is largely protective in nature, and that it has been adapted to perform this function. If

it possessed high osteogenic powers the repeated trauma to which it is continually subjected would result in extensive pro-

Six cases were treated by external fixation only, with a period of disability averaging 10.65 weeks. Six cases were

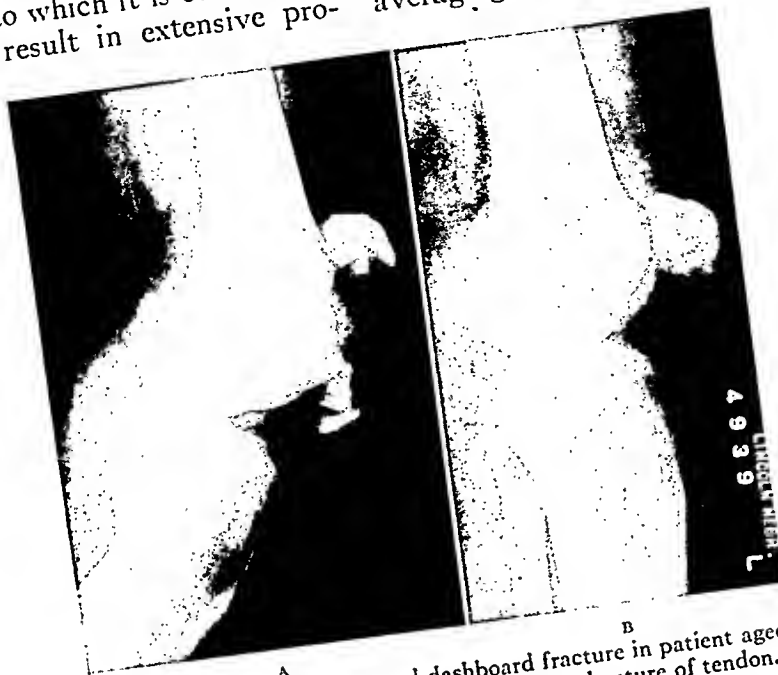


FIG. 4. A, severely comminuted dashboard fracture in patient aged 68. B, one year after excision of fragments and suture of tendon.

liferative changes, which would soon have a deleterious affect upon the knee joint itself.

Reports of the period of disability following fracture of the knee-cap vary considerably, some authors reporting as low as from three to four weeks, and others as high as from three to six months. Some variation in criteria for determining the end of disability doubtless accounts for a considerable part of this seeming discrepancy. A bookkeeper may be able to get about fairly well and do his usual work in a considerably shorter time than a ditch digger, and it would seem that if actual disability was considered to exist until the individual was able to do heavy duties that the statistical results might be more uniform, or at least would have more meaning. In the present series twenty cases could be traced definitely, and the period of disability was estimated to that time when the patient was able to resume heavy duties with a range of at least 90 degrees motion and good quadriceps strength.

treated by open operation and fixation with an average period of disability of 17.65 weeks. In eight cases of comminuted fractures treated by excision and primary suture of the remaining fragment to the extensor apparatus, the average disability was 10.75 weeks; only slightly longer than those cases of fracture presenting little or no separation, which were treated by external fixation only. Of the six cases treated by casts alone, all had good functional results. Of the six cases treated by open reduction and fixation, four had good results and two only fair. Of the eight comminuted cases treated by excision and primary suture all had good end results. In no instance was it felt necessary to excise the entire patella, although in certain severely comminuted cases this procedure might be warranted.

In one case treated by excision of fragments and direct tendon suture, disability was prolonged to sixteen weeks. This case deserves special mention because it emphasizes the importance of proper after-care.

In this instance coöperation could not be obtained and the knee was kept immobilized for one month when the patient failed to return as requested. At this time the patellar fragment was found in good position. This patient was not seen again for two months, during which time he carried out daily stretching of the knee to increase motion, and got about only with the aid of crutches. At the end of this period the newly repaired tendon was found to be lengthened over an inch, the patellar fragment riding high, and the quadriceps muscle very weak. Tendon shortening was refused but an active exercise program was agreed upon. At the end of a month the patient was able to demonstrate full range of motion with good quadriceps strength, although the patellar tendon was no shorter.

While this series is admittedly too small to allow any final conclusions, it is the impression of the author that the period of disability to be anticipated following any severely comminuted fracture of the patella, in which one fair-sized fragment remains either at the upper or lower pole, is greatly reduced by early excision of the comminuted fragments and direct suture of the extensor apparatus to the remaining fragment, together with careful repair of all injuries to the lateral extensor apparatus. The saving of a portion of the patella retains effectively the protective function which we feel it subserves in relation to the knee joint.

The operative procedure used in these cases is essentially that reported by Thomson<sup>9</sup> in 1934. A free lateral patellar incision exposes the fracture site fully when the skin and subcutaneous tissue have been reflected. The fragmented portion of the bone is carefully excised and the blood clots removed from the anterior chamber of the knee. Two drill holes are placed longitudinally through the remaining fragment in such a way as to afford firm anchorage to a strong kangaroo tendon or living fascia suture. This suture is then imbricated in the central portion of the tendinous exten-

sor apparatus, whether it be at the upper or lower pole, and with the knee extended and the patellar fragment approximated,

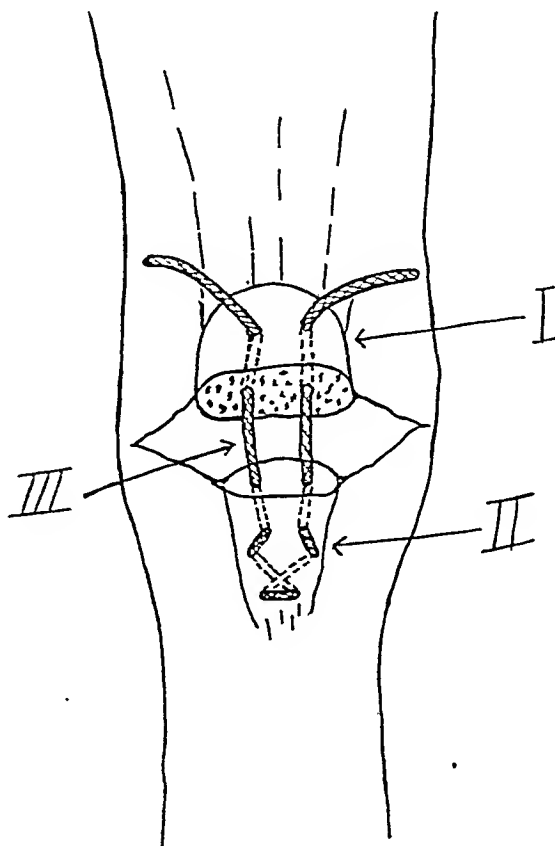


FIG. 5. Method of imbricating suture in patellar tendon. A firm suture, deep in the patellar tendon is essential. Kangaroo tendon preferred because of strength, availability, and ease of use.

the suture is passed through the drill holes and firmly tied. Careful repair of any lateral tears of the capsule is made, and the superficial portion of the ligament approximated, after which 20 c.c. of amniotic fluid are injected into the joint space and the wound closed. The use of amniotic fluid in the knee joint following arthrotomy has been practiced routinely for the past four years, and clinically we have felt that post-operative reaction is lessened and functional recovery accelerated, probably by minimizing the formation of interarticular adhesions and reduction of hemorrhage.

A posterior straight leg splint is applied and the patient is allowed to be about with crutches at the end of six to ten days. Early active motion is instituted in from ten to fourteen days, and splinting is discarded

in from fourteen to twenty-one days, the patient being instructed to bear weight in the straight leg position and increase the range of motion as rapidly as possible by active use. Muscle training and massage are very helpful in aiding early activity and definitely shorten the period of disability. Passive stretching is never used. After three to four weeks the patient is encouraged to discard crutches and get about with a cane only. At first motion is usually quite limited, but with early active function contracture of the powerful quadriceps muscle is prevented and, as the sutured patellar tendon becomes stronger, the range of motion is gradually increased by the activity of the patient and the quadriceps muscle lengthens the small amount necessary to accommodate the new relationship. Several have returned to clerical and light occupations at the end of two to four weeks. We have not observed any case in which a full functional recovery occurred in less than eight to ten weeks. It has been our practice to delay operation on these cases for a period of twenty-four to seventy two hours, during which time the leg is immobilized in a posterior splint; shock is overcome; the swelling reduced by a compression bandage, ice bags or aspiration; and the skin properly prepared for surgery. Complicating injuries are not infrequent and must receive adequate consideration.

#### CONCLUSIONS

1. Dashboard fractures of the patella are increasing frequently and present an un-

usual degree of comminution of the bone. Accurate reduction and fixation of these fractures is often impossible.

2. The presence of the patella, although adding little to the mechanical efficiency of the knee, exerts a beneficial influence through its action in protecting the extensive cartilaginous surface of the femoral condyles, and its preservation is urged where possible.

3. Excision of fragmented portions of the bone, followed by suture of the extensor ligaments to the remaining fragment, retains this protective function and shortens the period of disability which follows these severe injuries.

4. Many injuries resulting from being thrown against the interior of a car at the time of accident might be prevented by better designing of automobile interiors. Suitable padding and the use of some type of automobile safety belt is offered as a possible solution.

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# THE ROLE OF THE CORACOCALVICULAR LIGAMENTS IN AFFECTIONS OF THE SHOULDER GIRDLE\*

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NEW YORK CITY

THIS study was stimulated by the remark of a mature orthopedist, John Ridlon, who at the meeting of the Chicago Surgical Society in 1922, said "... that the difficulties encountered in treatment of injuries to the shoulder joint have always been more troublesome and more obscure than the difficulties in treating all other joints together." We may safely add that these difficulties are, at least in part, due to our limited knowledge of the underlying pathology.

At the United States Public Health Service Out-Patient Clinic in New York City, we had in a period of ten years 4,000 patients who complained of pain in the shoulder girdle, constituting 4 per cent of all persons x-rayed at this clinic. Over 98 per cent were male. Merchant seamen and W.P.A. workers of equal number constituted 70 per cent of the total, referred for treatment and for decision on period of disability; longshoremen represented 16 per cent, referred by the Referee Commissioner, for guidance in adjustment of patients' claims against the insurance carriers; United States Employees Compensation Commission cases—9 per cent—referred to the clinic for treatment, or for deciding disability and adjustment of claims; and other beneficiaries—5 per cent—for treatment and claims. Almost all the patients had filed claims, and we had to referee these claims, sometimes before and sometimes after corrective measures had been instituted.

Out of the total number, 1,800 cases were studied in detail; only 28 per cent showed positive x-ray findings on the ordinary anteroposterior view. With the addition of

the oblique view which we instituted in 1928 in accordance with the suggestion of King and Holmes<sup>1</sup> of Massachusetts General Hospital, the number of positive cases was increased to 32.4 per cent. The reasons for this low percentage of positive x-ray findings have been discussed in one of our recent publications.

This communication deals with the thirty-six patients who had abnormal x-ray findings pertaining to the coracoclavicular region. Since this topic has received so little mention and attention, it is desirable to review it.

Picture a woman of 38, lifting a wash boiler from the stove to the floor. She is startled by something dropping on the floor with a bang, and conscious that she is losing her grip on the handle in her right hand and aware of the boiling water in the boiler, she strains herself with all her energies to hold up the other end to minimize the injury. Nevertheless she sustains a scald on her left foot, an incomplete fracture of the great toe of the left foot, and pain in the left shoulder. A week later the burn and fracture of the foot trouble her no longer, but she persists in complaining of pain in her left shoulder. We say she sprained the shoulder. What does that mean? What has happened to it? In what way can we remedy her disability and discomfort?

Or let us take this example: An executive is holding an important telephone conversation. The noise outside his room interfering, he reaches out with his right hand as far as possible to grasp the knob to shut the door. Unable to reach the knob, he grasps the side of the door and in trying to shut it,

\* Approved for publication by the Surgeon General, U. S. Public Health Service.

his arm swings backwards. He experiences a slight pain close to the angle of the right scapula, and a much sharper pain in the middle of the upper border of the scapula. For weeks he complains of inability to put on his coat or play golf. He has no tender areas over the subacromial region, but he does have a point of tenderness over the coracoid and another one in the posterior part of the scapula, at a point 1 inch from the middle of the superior border. An x-ray examination of the shoulder discloses no abnormality of the scapulohumeral, acromioclavicular, or acromiohumeral region, and hardly any findings in the coracoclavicular region. We diagnose his case "sprain of the shoulder." Wherein lies his trouble?

Or imagine a young football star diving for the ball and landing on his right side. His opponents pile up on his left side, especially the left arm. The humerus does not give, but the whole shoulder does. The scapula is suddenly pushed towards the young man's spine. The clavicle overrides the acromion, and the coracoclavicular ligaments stretch. What is more important, the man can no longer push or pull with the left arm without discomfort and pain even on simple swinging of the arm. He has no evidence of fracture or dislocation of the acromioclavicular joint, but he is incapacitated for the entire season. The condition is also diagnosed "sprain." But of what part?

Or take the case of a longshoreman who had sustained a dislocation of the acromioclavicular joint. For a while his arm was placed in a sling. When this failed to relieve the pain open reduction was done and two loops of wire were placed between the clavicle and the acromion. After a short time he returned to his work and the very same day he again felt a sharp pain in the shoulder. An x-ray examination showed that both loops of wire had been broken, incapacitating the patient once more. What made this surgical procedure a failure can best be understood if we review the fundamentals of the entire problem, namely, the basis of support of the upper

extremity to the body, the main anchoring of the scapula on the clavicle, and in turn on the body, the limits of this anchoring structure, the coracoclavicular ligaments, the function of these ligaments, the evolution of the ligaments, the part they play in the movements of the upper extremity, and particularly the rôle they play in acromioclavicular dislocations.

The upper extremity is joined to the body indirectly, through the intermediary lever—the clavicle—which articulates with the sternum by a very strong capsular and accessory ligament, allowing vertical movement, anteroposterior movement, and axial rotary movement of minor extent.<sup>2</sup> Since the inner arm of this lever—the clavicle—is short, the outer arm (the longer one) has in turn much greater range of movement. To the clavicle at about the junction of the inner three-fourths and outer one-fourth, the scapula is joined by two strong bands placed in such a manner that when one is stretched the other is relaxed. (Fig. 1.) They are somewhat similar to the crucial ligaments of the knee but broader, especially at the clavicular attachment. To understand these important structures—the coracoclavicular ligaments—we had best digress to the evolution of the shoulder girdle in general.

In the lower vertebrates, such as the fish, where the body is supported entirely by the buoyancy of water, the clavicle is flat and is attached to the cleithrum in front, in a way similar to the attachment of the clavicle to the sternum in humans. The coracoid and scapula are represented as a single bone, attached to the clavicle by ONE BAND stretching from the top of the clavicle to the lower part of the coracoid in front and a similar BAND BEHIND. The humeri are short and attached by a universal joint to the scapulocoracoid. This is well adapted for steering and paddling movement; but the fins are not used either for support of the front of the body or for support of the entire body, as in primates. (Fig. 2.)

In the amphibia where the pectoral girdle is used for support and locomotion, a change occurs. The coracoid swings around

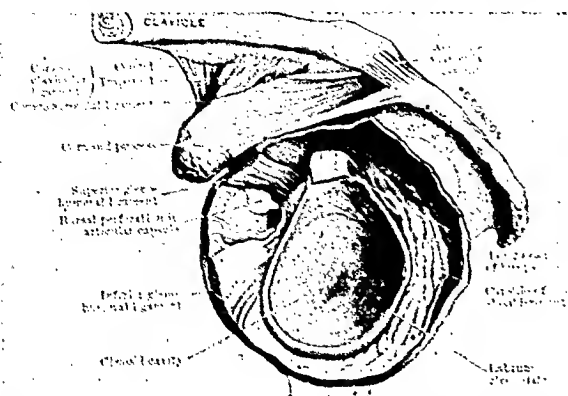


FIG. 1. Relation of the conoid and trapezoid ligaments to each other and to the conoid and clavicle. (After Cunningham.)

and bridges the side of the animal to the front, reaching almost the median line, and the clavicle is just slightly anterior or cephalad to the coracoid. The clavicle is bridged both medially and laterally to the coracoid by means of the remains of a reptilian structure, the precoracoid. The scapula, as continuation of the coracoid, becomes slightly angulated at about the glenoid cavity, facilitating support, steering and paddling functions of the upper extremities. The slight angulation of the scapula and the coracoid on the clavicle has turned the *front connecting band* slightly laterally, and the *back connecting band* of the clavicle slightly medially on the coracoid.

In a further stage of evolution, as in the marsupials, the coracoid is only a remnant seen in the embryo; in the adult animal it has receded laterally and is only a process of the scapula. The scapula has angulated further to the back and with it the front band of the clavicle to the coracoid extended more outward, and the back band more inward. In primates, especially in the human, the scapula is further angulated on the clavicle in order to give freer movement to the upper extremity, greater prehension and suspension functions. This has carried the anterior band of the clavicle more externally and the posterior band of the clavicle more internally on the coracoid;

and as a result we have a twist of the coracoclavicular ligament from the anterior part of the clavicle to the postero-external

#### DIAGRAM OF ATTACHMENT OF CORACO-CLAVICULAR LIGAMENTS

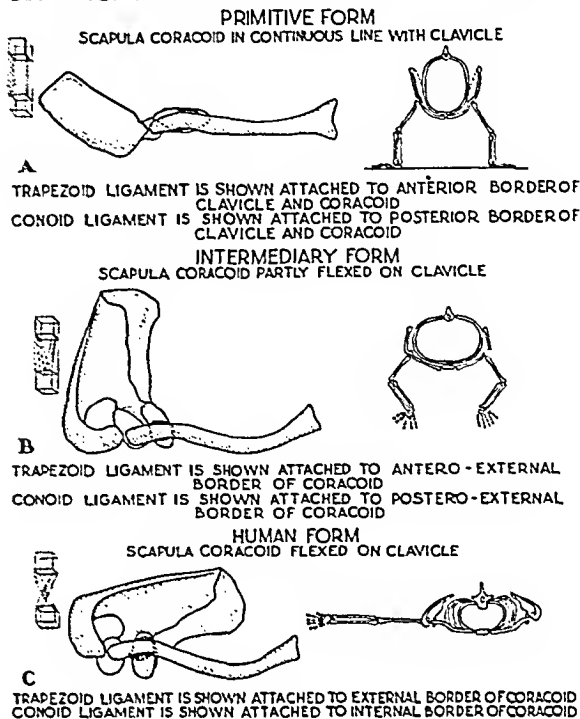


FIG. 2. Developmental stages of the angulation of the scapulo-coracoid to the clavicle and the associated torsion of the coracoclavicular ligaments. The anterior band of the clavicle turns outward with the anterior surface of the coracoid. The posterior band of the clavicle turns inward with the coracoid, resulting in anterior external and posterior internal ligaments respectively, similar to the crucial ligaments of the knee.

part of the coracoid, and from the posterior part of the clavicle to the antero-internal border of the coracoid, similar to the crucial ligaments of the knee. In the adult the ligaments have receded from their borders and have fanned out more on the clavicle than the coracoid. The intervening structure between the two bands has become liquefied into a bursa which keeps the clavicle from grating against the coracoid. Occasionally fibrocartilage intervenes. Huntington<sup>3</sup> claims that the coracoclavicular ligaments and the subscapularis muscle have their origin in the scapulo-sternal sheath of embryonal tissue which in lower animals gives rise to the scapulo-sternal muscles.

Cunningham's<sup>4</sup> description of the ligaments is as follows: "There is the strong

coracoclavicular ligament which binds the acromial end of the clavicle to the coracoid process of the scapula. It is readily divisible

trapezoid. It is narrow and pointed at its inferior end, to which it is attached to the superior aspect of the coracoid process, in

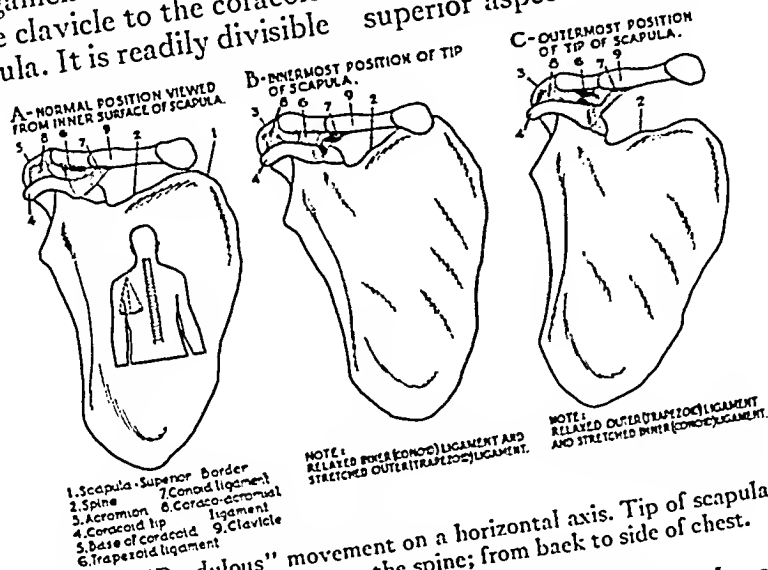


FIG. 3. "Pendulous" movement on a horizontal axis. Tip of scapula approaches or recedes from the spine; from back to side of chest.

into two parts, viz.: lig. conoideum and the lig. trapezoideum.

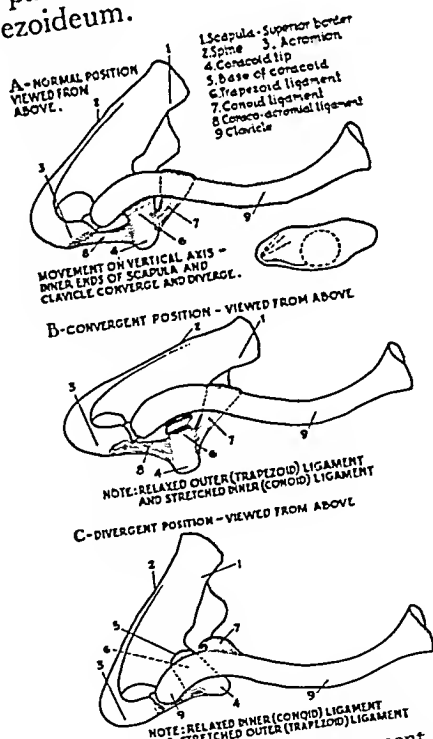


FIG. 4. "Hinged" movement of scapula on clavicle on a vertical axis; the vertebral border of the scapula approaches or recedes from the clavicle.

"The conoid ligament (Fig. 1) is situated medial to and slightly posterior to the

close proximity to the scapular notch. Its superior end widens out in the manner expressed by its name, and is attached to the coracoid tuberosity of the clavicle.

"The trapezoid ligament (Fig. 1) is attached inferiorly to the superior process of the posterior half of the coracoid process, lateral and anterior to the attachment of the conoid ligament. Superiorly it is attached to the ridge on the inferior surface of the acromial end of the clavicle. Its lateral and medial borders are free. Its anterior surface is principally directed upwards and its posterior surface to a similar extent looks downward.

"A mucous or synovial bursa usually occupies the re-entrant angle between these two ligaments."

Once we realize the position of these two ligamentous bands we can then follow carefully the nature of the movement of the scapula on the clavicle which these bands allow. Once more let us state that the major anchorage of the scapula to the clavicle is through the coracoclavicular ligaments; the acromioclavicular ligaments are only a later developed structure, i.e., an accessory stabilizer rather than a primary stabilizer of the shoulder girdle. (Experimental proof is forthcoming.)

## II

The movements of the scapula on the clavicle can be best understood if we pic-

scapula on the clavicle. (Fig. 5.) The inferior border of the scapula moves closer to the spine, stretching the outer band,

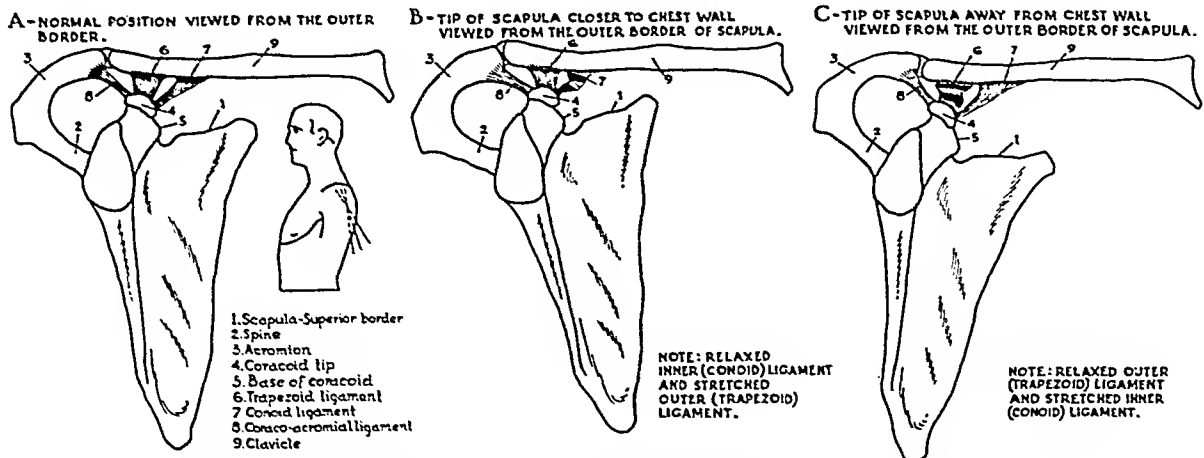


FIG. 5. "Winged" movement on horizontal axis at right angles to pendulous movement. Tip of scapula approaches or recedes from the chest wall.

ture a hinged type of universal joint, hooked to the clavicle on one end and to the coracoid on the other end; with this addition—that the part attached to the coracoid is also pivoted. As a result we have three kinds of movements which are usually associated with each other in life but which can best be analyzed separately. To follow the simile of the universal joint with the pivot, we have one movement in the horizontal plane, the axis of the movement parallel to the spine of the scapula, the top of the scapula moving backward when the lower part of the scapula moves forward, and vice versa. (Fig. 3.) When the top of the scapula is closer to the clavicle the outer band is stretched. When the top of the scapula is further from the clavicle, the inner band is stretched.

The second movement of the scapula on the clavicle is on a vertical axis, at right angles to the former movement, centered on the coracoclavicular ligaments. (Fig. 4.) When the vertebral border comes closer to the back of the patient, the inner band is stretched; when the vertebral border is away from the chest (as in wing scapula) the outer band is stretched.

The third movement on the pivot is on a horizontal axis and could be best described as a pendulous movement of the

and when it moves away from the spine it stretches the inner band. In addition there is a combined movement in pulling and pushing that one must understand clearly. In pushing backward with the arm outstretched, as in the case of the executive closing the door, or by the pulling forward of the arm by the wash boiler, or swinging of an ax, the conoid ligament is stretched. In the sudden push on the arm and scapula of the football star, or in a fall on the shoulder with arm at the side or arms outstretched in scarecrow position, the trapezoid ligament is stretched. In pushing with both arms forward the strain is on both ligaments.

Our digression has taken us through the evolution of the band, the coracoclavicular ligaments, the function of these ligaments and their relation to the minor injuries. But we have as yet failed to show the important part these ligaments play in acromioclavicular dislocation. Every dislocation of the acromioclavicular joint carries with it an associated injury to the coracoclavicular ligaments. At times the indication of injury to the coracoclavicular joint and its extent is properly gauged by the extent of separation of the acromion and the clavicle. But sometimes the clavicle may be spontaneously reduced to its nor-

## Liberson—Shoulder Girdle

mal position or to almost normal position, thus masking the extent of the injury to the coracoclavicular ligaments. It is there-

scapula on the clavicle, and unless the operation has done it, it is entirely unjustified.

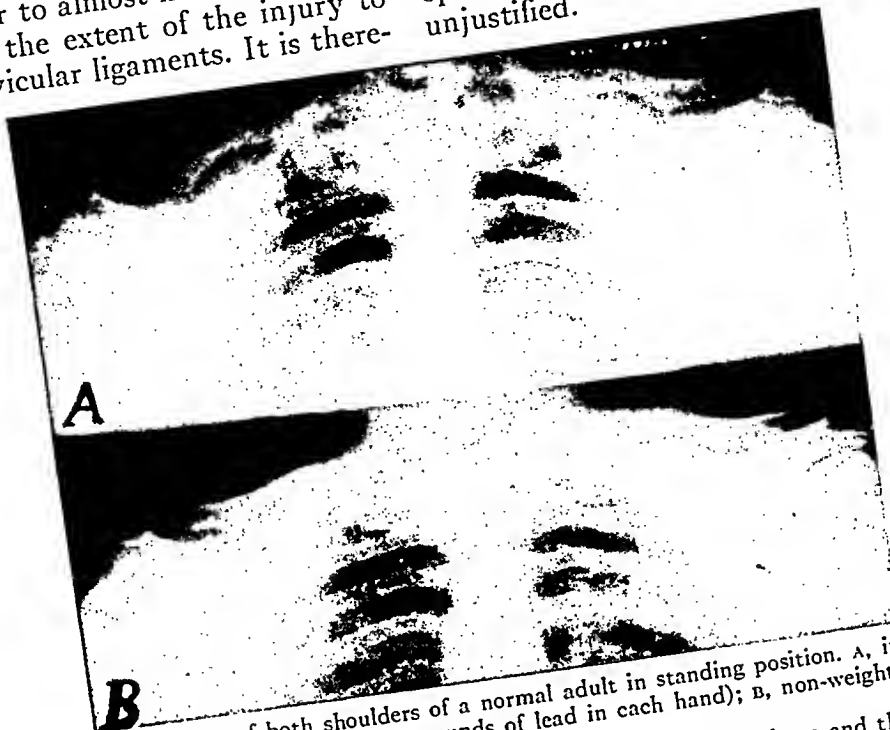


FIG. 6. View of both shoulders of a normal adult in standing position. A, in weight-bearing position (35 pounds of lead in each hand); B, non-weight-bearing position.

Note that the width of coracoclavicular space is greater above and the superior vertebral borders of both scapulae (touched up) are slightly lower with reference to the clavicles in the weight-bearing than in the non-weight-bearing position.

fore well to x-ray the patient in the standing or sitting position while he is holding a 35 pound weight in each hand, before a negative report of injury to coracoclavicular ligaments is rendered. (Fig. 6.)

There is one more point I desire to stress here before returning to the clinical material—that in the repair of the coracoclavicular ligaments the surgeon must pay particular attention to the direction of these bands and try to reconstruct as much as possible the direction and tension of the fascia or other material used in reconstruction so as not to allow too much space between the clavicle and coracoid (8 to 10 mm.) and in that way weaken the stabilizing influence of the coracoclavicular ligaments. On the other hand, they should not be made too tight, for this diminishes the flexibility and ease of the movements of the shoulder girdle. The reconstruction of the ligaments aims at stabilizing the

## III

From the x-ray viewpoint, the clinical material may be grouped so far under two main headings with subgroupings:

1. Injury to the coracoclavicular ligaments without dislocation of the acromioclavicular joint:

- (a) Simple sprain of the coracoclavicular ligaments, either conoid or trapezoid, or both.
- (b) Tearing of conoid or trapezoid ligaments, seen by x-ray in weight-bearing position.

2. Injury to the coracoclavicular ligaments with associated acromioclavicular dislocation:

- (a) The acromioclavicular dislocation was reduced spontaneously; the coracoclavicular ligaments never healed, or healed by calcification.

- (b) The acromioclavicular joint was reduced surgically and held by either sutures, wires, or fascia, is unable to use the arm to its fullest extent. There is restriction towards the end of every type of movement. Passive

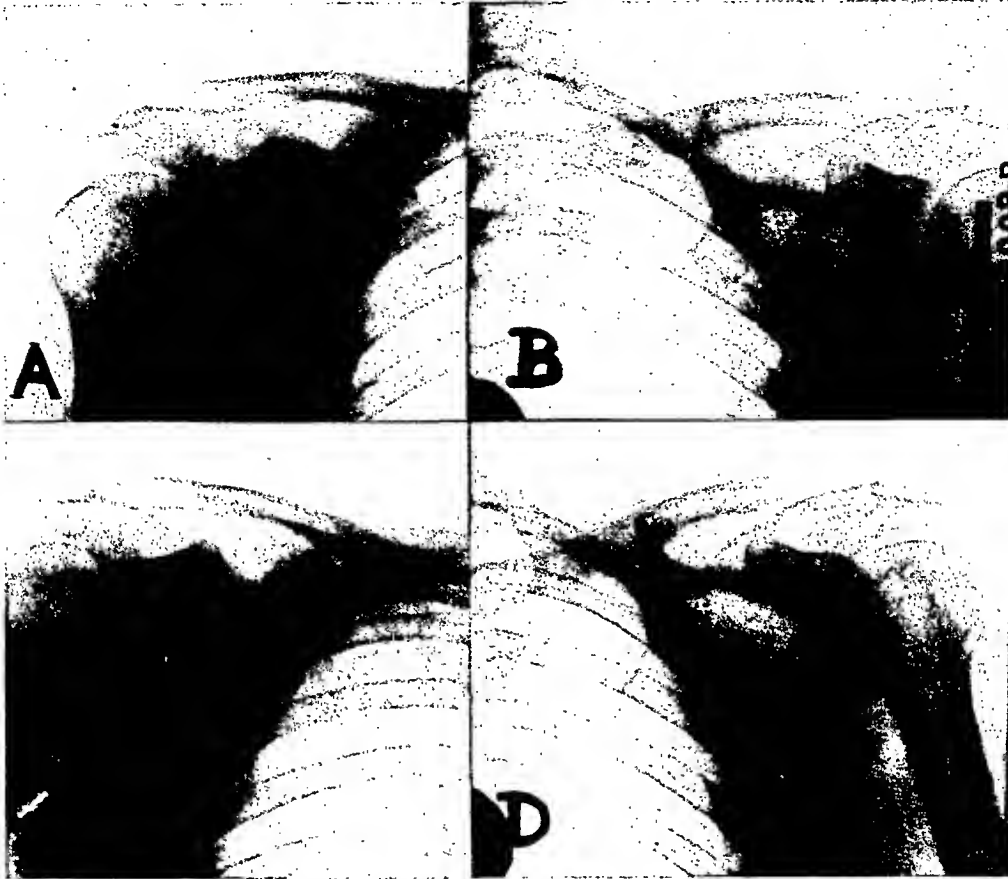


FIG. 7. View of both shoulders of a woman (M. L., age 36) who sustained an injury to the left shoulder as a result of sudden traction of a full wash boiler. A and B, in the weight-bearing position; c and D, without the weights. Note the slightly lower position of the vertebral border of the (normal) right scapula (B) in the weight-bearing as compared with (D) the non-weight-bearing position. The left (sprained) shoulder shows a higher position in the weight-bearing exposure of A, as compared with the non-weight-bearing position (C). Apparently the muscles of the left shoulder are substituting for the coracoclavicular ligaments and overcompensate.

but the coracoclavicular ligaments were ignored in the operation.

- (c) Coracoclavicular ligaments were repaired surgically but for some reason the operative repair did not stabilize the scapula on the clavicle (too much space).

1a. *Simple Sprain of the Coracoclavicular Ligaments.* (Example: Executive with door-knob and woman with wash boiler.) This condition usually results from an overstretching of the arm in the scarecrow position, or sudden tension during weight bearing in the forward position. The patient

motion will complete the movements without discomfort. There are usually two points which are more sensitive than the other parts of the shoulder; one is the tip of the coracoid which is more sensitive than its mate, the other point is at the middle of the superior border of the scapula.

The immediate x-ray findings are meager. At times there may be seen slight increased density in the region laterad to the border of the trapezoid ligament; but this region can be visualized only by use of a very fine technique. The x-ray examination in the weight-bearing position gives negative or paradoxical findings. (Fig. 7.)



Instead of the upper medial (vertebral) scapular border becoming lower as compared with the non-weight-bearing position

a second stage of injury to the coracoclavicular ligaments, and is exemplified by the football star falling on the side,

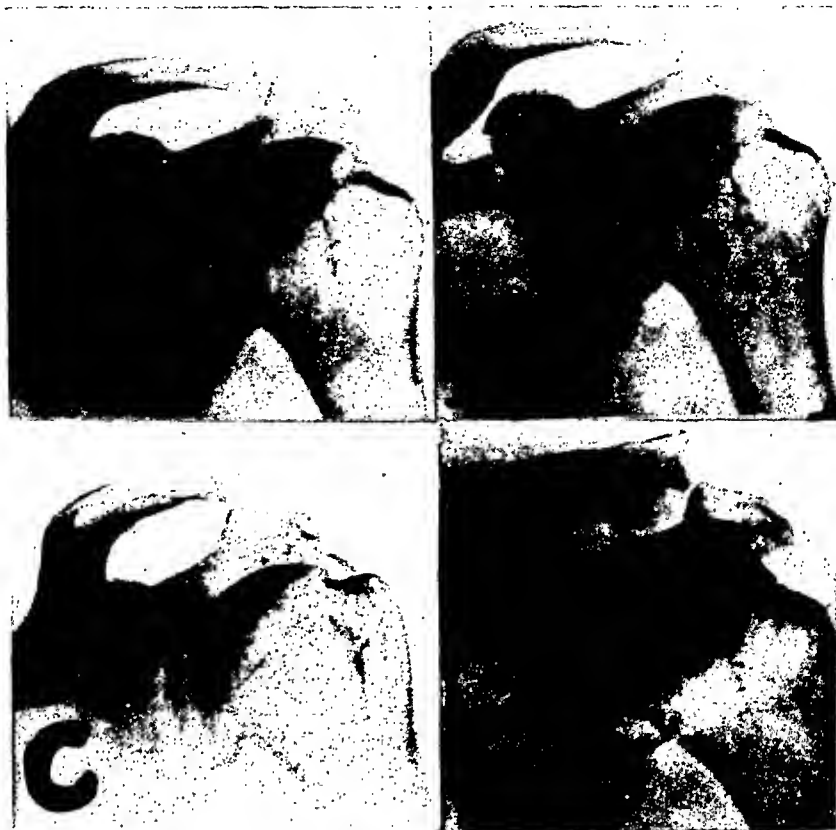


FIG. 8. View of the left shoulder of a male (K. G., age 64). A and B were taken the same day after he was struck by an auto on the left shoulder. They show the position of the clavicle slightly above the level of the acromion but still within upper normal limits. C was taken in the same standing position, but patient held a 35 pound weight in each hand during x-ray exposure. It shows the clavicle entirely above the level of the acromion, justifying a diagnosis of torn coracoclavicular ligaments with acromioclavicular dislocation. D, taken nine weeks later. Shows the calcification in the region of the coracoclavicular ligaments, substantiating the former diagnosis of injury to the coracoclavicular ligaments with acromioclavicular dislocation.

it actually appears higher. Apparently the reënforcement of the muscles is greater, due to loss of reliance on the ligaments.

The relief for such conditions has often been accomplished by attempting to bring these ligaments in the most relaxed state, namely the scapula as high and as nearly on line with the clavicle as possible. This is accomplished by a Velpeau bandage or holding the arm in a sling in front of the chest.<sup>5</sup>

*1b. Tearing of Conoid or Trapezoid Ligaments, or Both.* This might be called

with the arm in anatomic position. This condition usually results from stretching of the ligaments to a point of actual tearing. Here there is greater limitation and restriction in the use of the arm to its fullest extent than in simple sprain. There is restriction in the beginning and end movements, especially with lifting weights or pushing weight. Pulling on the arm may elicit a "catch" (a point in movement of quick passing pain but not sharp pain, which rapidly disappears when the point is passed). The two points of tenderness are

also present\* as frequently as in simple sprain, namely: a point of tenderness over the superior border of the middle of the

The relief of this condition is the same as for sprain. My personal experience in following these cases makes me think that

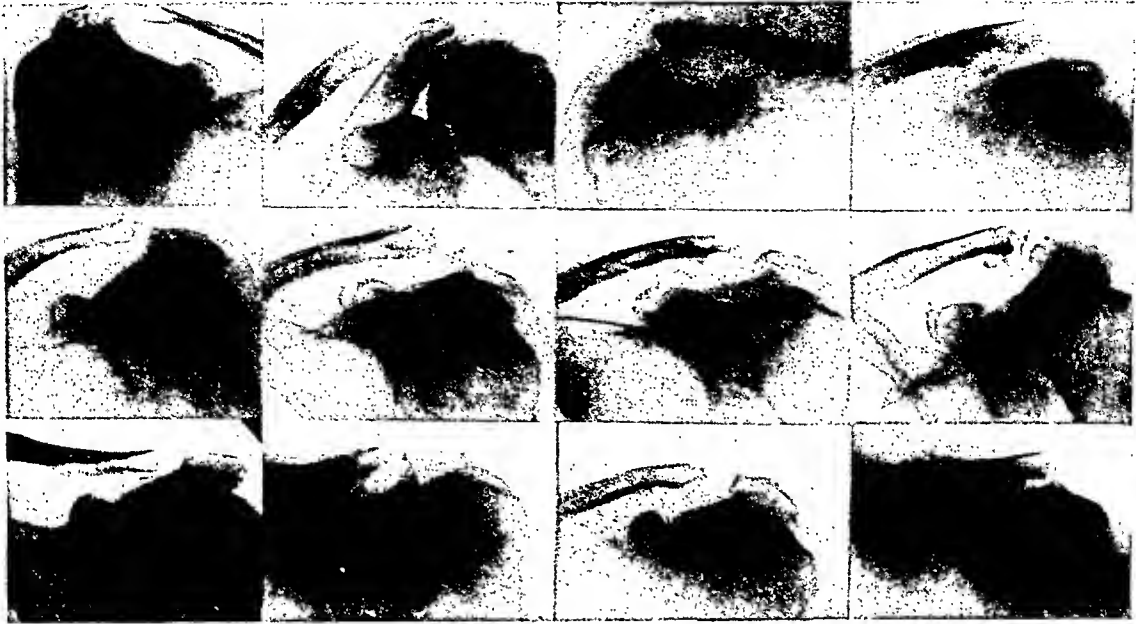


FIG. 9. After-effects of tearing of the coracoclavicular ligaments associated with acromioclavicular dislocation without any medical attention. The cases are arranged according to length of time from the injury to the x-ray examination. The first column on the left (three cases) within one month after injury: second within three months: third within nine months: and fourth over one year after injury. All these patients had some difficulty in lifting weights, or on prolonged pushing of hand truck or in pulling a rope.

Note that the greatest calcification at the base of the coracoid (middle row horizontal) is in those cases which have the greatest widening of the space between the coracoid and the clavicle, evidencing greatest injury to the conoid ligaments. In the other cases the greatest calcification is nearest to the dislocated acromioclavicular joint.

scapula and over the coracoid (more than its mate). The immediate x-ray findings are negative. Even after injection of air at the site of the ligaments the condition cannot be ascertained because of the great anatomic variation in size and thickness of the ligaments. However, when the x-ray exposures are made in the weight-bearing position and compared with the non-weight-bearing, the affected side shows a greater widening of the coracoclavicular space and greater lowering of the upper inner (vertebral) border of the scapula on the clavicle. (Fig. 8.) Superimposing the weight-bearing on the non-weight-bearing exposure facilitates recognition of the width of the space between the coracoid and the clavicle and tends to crystallize the findings.

\* The number of cases is not sufficient for statistical study.

if the condition is not improved in two weeks, surgical repair might be advisable in order to avoid the excess of calcium or other solid tissue deposit in the region of the torn ligament, which interferes with smooth and proper function of the shoulder girdle. This view, however, is not favored by one of the leading orthopedic surgeons in this city.

*2a. Spontaneous Reduction of Acromioclavicular Dislocation.* These injuries are usually similar to those of the last group. They are more often associated with a fall, the arm being in a position to resist the fall, and not in the anatomic position. Or it may follow a blow by a heavy object on the lateral border of the shoulder, not directly inward but slightly downward and inward, the force being greater on the scapula than on the humerus. It also occurs when a heavy weight is lifted by a group of men

(such as the lifting of a crate by four men) and the crate is accidentally released on one side by two men, which results in a

If the force is too great, however, the ligaments are torn. There is restriction and pain on movement, especially on lifting



FIG. 10. End results of improper repair of acromioclavicular dislocation because of faulty conception of the underlying pathology. A, a longshoreman who sustained a dislocation of the acromioclavicular joint with tearing of the coracoclavicular ligaments. An immediate open reduction was done, with insertion of two wire loops through the acromion and the clavicle for retention. After a period of about three months, the patient returned to his usual duties and the same day broke both loops of wire and was again disabled. B, a similar case in which non-opaque suture material was used. Note the greater displacement of the lower clavicle as compared with the upper; apparently the wire loops were still serving some purpose on account of inflexibility while the suture material used in the case of the lower figure was flexible and as soon as it tore it pulled out of the holes and the dislocation was again complete.

sudden pull on the coraco-clavicular ligaments of the other two and sometimes even on the supraspinatus tendon if the weight is very heavy. The same condition results in athletes on sudden striking the horizontal bar.

In fact, any condition which tends to separate the ligaments by force, as in the case of an athlete suddenly striking the horizontal bar, produces the same injury.



FIG. 11. G. C., male, age 50. Injured as result of a fall of one end of a 600 pound pipe (which pinned patient to floor) resulting in dislocation of acromioclavicular joint and tearing of the coracoclavicular ligaments. Operation was done at one of the leading hospitals in New York. Fascia lata from the right iliotibial tract was used around the clavicle and coracoid; rope silk stay suture was looped through drill-holes in acromion and clavicle; Stimson dressing was applied. Patient was discharged on eighth day.

A, five weeks after operation, patient incapacitated for duty. Note slight calcification in the conoid and trapezoid ligaments and moderate separation between the coracoid and clavicle. B, eight months later. Note two calcified areas, one in the region of the torn conoid and the other in the region of the torn trapezoid ligament. Space between coracoid and clavicle still widened and patient was still incapacitated for his duties as longshoreman.

and pushing. On physical examination there is a drooping of the shoulder and prominence of the acromial end of the clavicle which disappears on raising the arm passively. Abduction is limited by pain. The x-ray findings are: high position of the clavicle above the acromion, and marked increase in the space between the coracoid and the clavicle. In cases with incomplete dislocation, x-rays taken in weight-bearing state and in non-weight-bearing state will disclose the extent of

the injury; namely, a higher position of the clavicle above the acromion, low position of the upper inner border of the scapula and marked separation between the coracoid and clavicle. In young patients the dislocation is associated with incomplete tearing of the conoid and trapezoid ligaments. In older people, above the age of 35, when the dislocation of the acromioclavicular joint is complete there is usually complete tearing of the conoid and trapezoid ligaments. The x-ray films taken in the weight-bearing position usually disclose the extent of the injury and indicates the necessity of radical therapeutic measures. The relief of this condition is usually obtained by means of a Velpeau bandage, adhesive strapping, or a plaster jacket. More often, he is left alone and we find the end results of this form of treatment. (Fig. 9.)

The relief, although sufficient to reduce the dislocated acromioclavicular joint, does not favor the repair of the torn coracoclavicular ligaments. As a rule the patient is discharged six weeks after the injury as "cured" but he still has a weakened shoulder. This is the end result of inadequate therapy for the dislocation of the acromioclavicular joint with tearing of the conoid and trapezoid ligaments.

**2b. Surgical Reduction of Acromioclavicular Joint.** This group of acromioclavicular joint injuries is separated from the others by the fact that the cases although properly diagnosed at the very beginning clinically and substantiated by x-ray, the surgical repair undertaken was unsuccessful. The surgeon, unaware of the leading rôle played by the torn coracoclavicular ligaments in the dislocation of the acromioclavicular joint, performed an open reduction on the acromioclavicular joint by placing one or two sutures or loops of wire through the acromion and the clavicle, ignoring the associated injury to the coracoclavicular ligament. After a period during which the soft tissues have receded and the infiltration absorbed, patients return to their duties only to find limita-

tion in motion. They are unable to push or pull with the arm, and quite often on the first effort of traction or pushing,

DOUBLE FIGURE EIGHT TYPE OF RECONSTRUCTION OF THE CORACOC-  
CLAVICULAR LIGAMENTS.

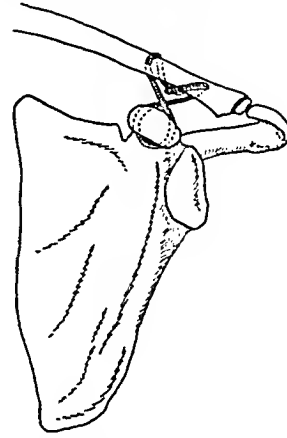


FIG. 12.—Shows what appears to the author as an ideal repair. A curved incision over the clavicle from the acromion to the inner third; two drill-holes through the vertical diameter of the clavicle 1 and 2 inches from the end respectively. A strip of fascia 7 inches long, doubled, is first threaded through the outer hole of the clavicle from above downward. A pair of curved artery clamps is inserted under the coracoid, directing the clamps from the outer border inward, between the muscle attachment (coracobrachialis pectoralis minor biceps) and the base of the coracoid. The fascial sheath is now pulled over the inner part of the coracoid and fed into the jaws of the clamp. The clamp is slowly withdrawn until the jaws clear the coracoid; then the clamp jaws are pushed above the coracoid. From there the fascial sheath is threaded into the inner hole of the clavicle from below. The ends are then brought together, the outer end from in front above and the inner end from the back to the undersurface of the clavicle sutured. Care must be taken to bring the scapula as close as possible to the clavicle by manipulating the arm before the ends of the fascial sheath are sutured. A supplementary suture between the acromion and the clavicle for stabilization would be in place for greater security.

the splinting material (wire, kangaroo tendon or fascial sheath) breaks. They then return to the clinic with a recurrent dislocation. (Fig. 10.) It is evident from what has been said so far that the important structures which the surgeon failed

to reckon with are the coracoclavicular ligaments.

### 2c. Operative Repair of Coracoclavicular

than  $\frac{1}{4}$  inch separation between the coracoid and the clavicle, he will then avoid the pitfalls of improper repair. (Fig. 12.)



FIG. 13. Shows four cases of post-traumatic ossification. A, over three months; B, over six months; C, over nine months; D, who claimed an injury only two days prior to the taking of the x-ray and denied any previous injury. The ossification in the clavicular part of the conoid and trapezoid was by its texture interpreted to be at least one year's duration. Note in C the complete ossification of the conoid and trapezoid ligaments particularly at the coracoid, while in D the ossification is further advanced yet not as complete. All four patients claimed greater tiredness in the affected shoulder than in the other although most of the pulling and pushing was done with the other. There was limitation in abduction; especially above the horizontal, and general sluggishness on movement in the affected shoulders as compared with the normal shoulders.

**Ligaments.** There is another group of acromioclavicular dislocation in which operation has been performed. However, in repairing the acromioclavicular ligaments, the surgeon has made the reconstructed ligaments too long (or, rarely, too short). (Fig. 11.) In either case he has not given the patient a restoration but only a substitution. If the surgeon is careful in reconstructing the coracoclavicular bands so that they extend from the posterior external part of the clavicle to the anterior internal part of the coracoid and from the external part of the coracoid to the anterior part of the clavicle, arched around the neck of the coracoid and part of the clavicle, with not more than  $\frac{3}{8}$  inch or less

This arrangement of a fascial band makes a figure eight, starting from a drillhole at the outer posterior part of the clavicle, about 1 inch from the acromion from above, winding around the inner part of the coracoid neck to the outer part of the coracoid. From here it goes to the inner anterior under surface of the clavicle through a drillhole 1 inch from the former, carried over the top to the front of the clavicle and joined to the other end of the band at the outer end of the clavicle beneath. In such a reconstruction there will be much less postoperative ossification and a weakened and painful state of the shoulder can be avoided.

The post-traumatic ossification of the ligaments, resulting either from injury to the coracoclavicular ligaments or from improper attention to the acromioclavicular dislocation with injury to the ligaments, causes considerable hardship and disturbed function of the shoulder girdle and I know of no procedure to alleviate it. (Fig. 13.)

#### SUMMARY

One thousand eight hundred Roentgen examinations of the shoulders of patients in the Out-Patient Service at U. S. Marine Hospital, New York, whose chief complaint was pain, were reviewed. Thirty-six patients showed local pathology of the coracoclavicular ligament. Of these, nine patients had a coracoclavicular joint, in five of which the joint was bilateral.

The important rôle of the coracoclavicular ligaments play in stabilizing the shoulder girdle, their evolutionary and anatomic analogy to the crucial ligaments of the knee joint, are pointed out.

The movements of the scapula on the clavicle in each of the three planes and the extent and limits of these movements by the coracoclavicular ligaments are analyzed and illustrated. The important rôle the coracoclavicular ligaments play

in sprains of the shoulder is illustrated by case reports. A method for the x-ray demonstration of severe injuries to these ligaments is introduced.

A clinico-roentgenologic division of the cases into two major groups is made, and the subgroups are illustrated by case reports.

An appeal is made for better evaluation of the importance of the coracoclavicular ligaments in acromioclavicular dislocations.

I wish to express my gratitude to Senior Surgeon J. Bolten for his kind coöperation, and to Miss Beatrice James, Winthrop D. Conklin and Hyman Vozick, for their untiring coöperation.

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# CHRONIC SPRAINED ANKLE

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CHRONIC sprained ankle is the result of either (1) an acute sprain that has not been given an opportunity to recover before it is subjected to normal use; or (2) one which has an inherent weakness associated with some imbalance of the foot, being subjected to constant stress through daily usage. An acute sprained ankle has both intra- and extra-articular manifestations, e.g., synovitis is intra-articular, whereas swelling and discoloration are extra-articular, due to the tearing of one or more vessels coursing between the skin and the ligaments with consequent extravasation of blood. This latter explains the diffused subcuticular discolorations.

An acute sprain may be one of three types, which are, in order of frequency and importance: (1) A simple overstress on the ligaments may occur, more often on the lateral than on the medial aspects. Occasionally, the anterior ligaments may be involved due to sudden plantar flexion and rarely the posterior group because of sudden hyperdorsal flexion. (2) Stress may develop upon the ligaments, accompanied by tearing of the periosteal attachment, more often of the anterior fasciculus of the external lateral ligament at its attachment either to the external malleolus or to the astragalus. (3) There may be a tearing of the lateral ligament, again more often of the anterior fasciculus. I have never seen a case of tearing of the lateral ligaments that was not complicated by dislocation or fracture in its early stages. I have, however, seen two which, several years after the injury, showed definite evidence of tearing of this portion of the ligament, without a history of either dislocation or fracture.

The symptoms of acute sprained ankle need no description, but the symptoms of chronic sprained ankle are so frequently misinterpreted that they do need exemplification. They are, in the first group, no swelling, no discoloration, freedom of motion except in adduction. The latter causes a slight complaint of pain which seems to be the limiting factor rather than any mechanical cause. There is often a complaint of vague pain in the ankle at all times, but the patients can do nothing more than point to the outer side of the ankle as the area involved. It is here that a knowledge of the attachment of the anterior fasciculus is absolutely necessary to the diagnosis. One adducts the foot and palpates lightly the anterior edge of the malleolus. The patient will immediately wince. If this sign fails, palpation over the astragalus at the site of attachment will cause complaint. In some instances, the tenderness is present at both sites. One need not try to recognize tenderness with the foot in a normal position—adduction is absolutely necessary. The explanation for this localizing tenderness and resulting discomfort lies in the stress that has been brought upon the attachment of the ligament to the periosteum resulting in a chronic periostitis which will not show in the x-ray.

In the case of actual tearing of the ligaments, one may find the tenderness at either site but there is something that is far more striking, i.e., loss of normal contour in the course of the ligament. The normal contour is replaced by a deep indentation which, when palpated, fails to show the normal resistance imparted by the anterior ligament.



In all these cases one finds an associated weak foot, with resultant misdiagnosis. The usual supportive treatment for weak feet fails, however, to solve this problem.

In the treatment of Type 1, immediate balancing of the foot by the use of a  $\frac{3}{16}$  inner heel wedge plus a  $\frac{1}{8}$  outer sole wedge is the first essential. One must remember that the inner heel wedge is not a panacea as is commonly believed, that many feet show a pronation of the heel with a varus of the forefoot. When one puts a wedge on the inner side of the heel it corrects the pronation of the heel but makes the varus of the forefoot worse, thereby increasing the imbalance instead of improving it. The use of the outer sole wedge will turn the forefoot at the mediotarsal articulation in such a way as to restore normal balance. This simple measure has been most satisfactory in the treatment of those patients who constantly turn their ankles. They have a tendency, figuratively speaking, to trip over the "flowers in the rug." Their ankles turn without apparent cause.

These corrections should never be placed in a heel which is higher than  $1\frac{1}{8}$ . In fact, the ideal heel should be either  $1\frac{1}{8}$  or  $1\frac{1}{4}$  in height, unless the tendo Achillis is so short that the heel height gives rise to marked discomfort.

If these cases are seen early, one may make a half-moon of felt whose concavity corresponds with the shape of the malleolus, and then apply a Gibney boot or a modification thereof to hold the felt in place. This, with the corrective shoes, frequently is all that is necessary.

However, if the case is an old one, ionization is recommended, with tincture of iodine over the affected area and employment of the negative pole of the Galvanic current. Either a spongiopiline electrode or a flat metal one wrapped in absorbent cotton may be used, but either should be wet with normal salt solution. If drying occurs during treatment, moisten the electrode as frequently as indicated. The positive pole is placed in any convenient

position and the current regulated to suit the comfort of the patient. If a battery is not at hand, indirect diathermy, but never direct, may be used. Short wave therapy has not given results in our experience. When there is no electrical apparatus, the use of local heat followed by massage with iodine ointment, mercurial ointment or methyl salicylate, 1 dram in lanolin to make 1 ounce, gives satisfactory results. Novocaine or other substance used by injection for localized pain has not proved of any value.

The second type of chronic sprained ankle is often referred to by its possessor as a swollen or fat ankle. The most annoying symptom is an enlargement about the external malleolus which swells at night and goes down in the morning. It usually overhangs the top of a low-cut shoe and is sometimes tender; however, as a rule, the chief complaint is the disfigurement. These swellings vary greatly in size from a small rounded mass the size of a plum to one which may be as large as half an orange. Upon close examination, they are found to be readily picked up with the fingers and moved over the underlying tissue. They usually lie in front and below the malleolus, but occasionally, the larger ones show a prolongation posteriorly to the malleolus. The fact that they are movable differentiates them at once from the common swollen ankle of injury or constitutional disease. They are semisolid in consistency and at times, if the skin is thin, definite lobulation can be found. These swellings are lipomata that have resulted from one severe or several minor ankle sprains where there has been hemorrhagic effusion with incomplete absorption. They are rarely, if ever, seen in individuals who have a well-balanced foot although they may occur in these people following a severe sprained ankle with customary effusion of blood.

When pain is complained of, it is due to the same causes as in Type 1.

A third type of chronic sprained ankle is sometimes seen. Here there has been definite ligamentous tear, and instead of

enlargement and tumor growth, there is indentation. We have found one or two rather aberrant cases following severe ankle sprains where the condition has been more anterior than lateral. There has been exostotic development on the anterior part of the astragalus in such a position as definitely to block the dorsal flexion of the foot by impinging upon the anterior face of the tibia. In both cases the growth could easily be felt beneath the tendons. X-rays have proved the diagnosis and removal has brought about cure.

When the lipoma exists there is but one method of treatment, that is, operative removal. The operation is simple, but in thin-skinned individuals there is frequently trouble in skin healing. The tendency is for the edges to spread or at times to slough, giving rise to a disfiguring scar. I have tried various types of incisions about and over these growths but so far have not found one in which the edges will never slough. It is peculiar, however, that most women seem to prefer a disfiguring scar to the lipomata. If operation is refused, improvement is obtained in some cases by a corrective shoe which is well-balanced,

and which has a low-cut upper on the side where the lipoma is present. The higher the upper the more likely it is to throw the growth into relief unless a regular shoe with a top be worn, but with present style tendencies, a shoe with a top seems to attract far more attention than the swelling.

So far we have found no satisfactory solution to the cases in which the ligament has been torn years before. The best we can do with these is to apply the treatment for sprained ankle with periostitis. So far we have not attempted to repair the ligaments with fascia transplants. We question whether the operative procedure with the resulting scarring and the possibility of failure is not a worse cure than the disease for which it would be proposed.

#### SUMMARY

1. The common findings in chronic sprained ankle have been discussed.
2. We have attempted to point out the cause for many misdiagnosed cases of pain about the ankle joint.
3. Treatment which has been satisfactory in our hands has been suggested.



# CARDIOVASCULAR COMPLICATIONS OF FRACTURE\*

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CARDIOVASCULAR complications are directly or indirectly responsible for the great majority of deaths incident to fractures in elderly persons. In addition, manifestations of cardiac disorder are frequent during the convalescent stage of fracture and sometimes for an indefinite period thereafter. The important influence which fractures may exert upon the cardiovascular system is emphasized by these facts and is the subject of the following study.

The records of 500 successive cases of simple fracture from the wards of the Philadelphia General Hospital were analyzed with respect to location of the fracture, age of the patient, nature of any cardiovascular complications and mode of death. The series included fractures in all parts of the body except the skull, because the latter involves complications which are essentially neurologic. The patients were of both sexes and ranged in age from 15 to 92 years.

## RESULTS

*Mortality According to Age.* From Table I it is seen that the incidence of death among hospitalized fracture cases is conspicuously associated with advanced age. The mortality among all patients under 60 years of age was less than 2 per cent. Of the patients in the seventh decade, however, approximately one-fifth died, in the eighth decade, one-third died, and in the ninth decade and older, over one-half died.

*The Relationship of Associated Cardiovascular Disease to Mortality.* In persons over 60 years of age, the cardiovascular system is invariably the site of some degree of degenerative change. Such change is due

partly to the physiologic aging process of man and partly to a disorder which has been regarded as metabolic in nature and of which atheromatosis is a manifestation.<sup>1</sup> This factor is apparently the predisposing cause of the common type of death in elderly fracture patients.<sup>2</sup> Under the circumstances, it seemed justifiable to include all patients in this series who were over 60 years of age in the group which had associated (arteriosclerotic) cardiovascular disease.

TABLE I  
MORTALITY ACCORDING TO AGE IN 500 CASES  
OF FRACTURE  
Simple fractures of all types except fractured skull  
admitted to Philadelphia General Hospital

	No. of Cases	Deaths	Per Cent Mortality
Over 80 years.....	500	82	16
70 to 79 years.....	42	22	52
60 to 69 years.....	91	32	35
Under 60 years.....	82	19	23
	285	5	2

Table II indicates that among the total 500 cases of fracture, the mortality was 16 per cent. In 230 with associated cardiovascular disease there was a mortality of 34 per cent, while in the remaining 270 cases with no apparent cardiovascular disease the mortality was only slightly over 1 per cent. The presence of cardiovascular disease, therefore, increases the likelihood of a fatal outcome by approximately thirty times.

*Types of Heart Disease Complicating Fracture.* The apparent type and extent

\* Read before the Annual Meeting of the Interurban Orthopedic Club, Philadelphia, October 7, 1938.

TABLE II  
INCIDENCE OF CARDIOVASCULAR COMPLICATIONS  
IN 500 CASES OF FRACTURE

	No. of Cases	Deaths	Per Cent Mortality
No associated cardiovascular disease.....	270	3	1
Associated cardiovascular disease; all ages.....	230	79	34
Associated cardiovascular disease; over 60 years.....	215	77	36
Associated cardiovascular disease; under 60 years.....	15	2	13

of the myocardial change as judged by the recorded murmurs, heart size and electrocardiogram showed surprisingly little correlation with the incidence of death, although this fact could not be evaluated statistically because of the lack of sufficient detail in the average cardiovascular examination of patients on large surgical services.

TABLE III  
TYPES OF CARDIOVASCULAR DISEASE ASSOCIATED WITH  
500 CASES OF FRACTURE, ALL AGES

	No. of Cases	Deaths	Per Cent Mortality
Arteriosclerosis; over 60 years old, with or without hypertension.....	215	77	36
Hypertension; under 60 years old, with or without arteriosclerosis.....	12	2	17
Rheumatic heart disease.....	1	0	0
Syphilitic heart disease.....	1	0	0
Phlebitis.....	1	0	0

Table III shows that the mortality was highest among patients who had arteriosclerotic cardiovascular disease either with or without hypertension. Of such cases, approximately one-third were fatal. Among patients who had hypertension and relatively little obvious arteriosclerosis, the mortality was one-half that of the preceding group. Only two patients in the entire

series had other types of heart disease; one was rheumatic, the other syphilitic; both recovered.

*Types of Fracture Complicated by Cardiovascular Disease.* In 72 of the fatal cases complicated by cardiovascular disease, the fracture involved the upper end of the femur and in most instances was intertrochanteric. In two cases the site of the fracture was the lower part of the femur, in two others, the tibia, and in one case each, the pelvis, humerus and clavicle. The hip is therefore the outstanding site of fatal fractures.

TABLE IV  
TYPES OF FRACTURE PRESENT IN 79 FATAL CASES  
COMPLICATED BY CARDIOVASCULAR DISEASE

	No. of Cases
Upper femur (mostly intertrochanteric).....	72
Lower femur.....	2
Tibia.....	2
Pelvis.....	1
Humerus.....	1
Clavicle.....	1

*Mode of Death.* On the clinical records, numerous different diagnoses were used to explain the occurrence of death among patients who had associated cardiovascular disease. These included arteriosclerotic heart disease, hypertension, bronchopneumonia, uremia, infection and other conditions. However, the mode of death in almost all cases was strikingly similar, as were also the pathologic changes.

The common pathologic feature on post-mortem examination in the great majority of cases consisted of generalized passive congestion, particularly of the lungs and abdominal viscera, with little or no clinical edema. Some patients had various degrees of bronchopneumonia. Except for cases of longstanding hypertension, few had any significant enlargement of the heart such as occurs in congestive heart failure. Evidence of recent myocardial infarction was also unusual although coronary sclerosis and myocardial fibrosis were rather consistently present.

The common clinical feature of these cases was gradual and progressive weakness

accompanied to a variable degree by mental deterioration, renal insufficiency, hypostatic pulmonary congestion and terminal bronchopneumonia. Death of this type occurring in elderly patients has been attributed to diminution of venous return flow to the heart due to physical inertia.<sup>2</sup> The underlying pathologic fault is apparently the sclerosis of the peripheral arterioles, the effect of which is to permit blood to remain in the venules. Stasis of blood in the periphery produces anoxia and increased permeability of the capillaries with loss of fluid into the tissues and decrease in circulating blood volume. If death occurs, it may take the form of renal insufficiency, infection or cardiac failure, but such events represent simply the terminal episodes.

#### DISCUSSION

*The Effects of Fractures on the Cardiovascular System.* Analysis of the 500 cases of fracture here presented indicates that the mortality in such cases is, with only a few exceptions, associated with the presence of arteriosclerotic cardiovascular disease and to a lesser extent, with hypertension. Death results from a type of peripheral circulatory failure described above, the mechanism of which closely resembles that of shock. It is for the most part a slow process which becomes conspicuous only after one or two weeks in bed, generally for a fractured hip, less often for other confining fractures. Confinement to bed with its consequent physical immobility is thus the most important manner by which fractures may exert a deleterious or even fatal effect upon the cardiovascular system. In the absence of arteriosclerosis, i.e., in the younger age groups, this effect is probably seldom if ever serious.

Of the other ways in which the cardiovascular system may be adversely affected by fracture, the next in importance is acute shock. The effect of acute shock is to produce a sudden decrease in the volume of circulating blood with a resultant generalized vasoconstriction, a tendency to pul-

monary edema and a decrease in the coronary circulation. In almost any case of heart disease, irrespective of type, in which the patient is bordering on congestive failure, such an event is obviously serious since it temporarily disturbs whatever compensatory mechanism has been established to prevent circulatory collapse. Areas of the myocardium which happen to be supplied by sclerosed coronary vessels may suffer from acute anoxia and actual infarction may result. Severe pulmonary edema is often precipitated. Serious arrhythmias may develop as a consequence of myocardial ischemia, direct nervous influences and the compensatory secretion of adrenalin.

Fractures may also affect the heart and circulation through the influence of pain. This factor is, of course, extremely difficult to evaluate but is nonetheless real. The effect of pain on the circulation is variable; moderate pain usually accelerates the heart rate and raises blood pressure while severe or long-continued pain may slow the heart rate and lower the blood pressure. As a rule, body metabolism is accelerated, the work of the heart increased and adequate rest may be prevented. Such disturbances are obviously capable of precipitating heart failure in persons suffering from various forms of myocardial impairment. Further potential effects include disorders of endocrine function such as the occasional precipitation of a thyroid crisis or even a pituitary syndrome.<sup>3</sup>

Not infrequently it is found that elderly persons who have sustained a fracture, especially one involving prolonged convalescence and considerable discomfort, suffer continuously thereafter from easy fatigue, breathlessness and vague precordial pains. The precise nature of what has taken place in the body to produce such an effect is often difficult to explain since no organic changes in the cardiovascular system are apparent. It is as if the patient has grown much older in a short period of time. Psychologic factors, especially pain and consciousness of any

residual disability due to the fracture, undoubtedly play a large part in many of these cases. In addition, however, it seems reasonable to presume that in some way tissue metabolism has been disturbed so that muscular movement is less efficiently performed and a greater strain is thereby placed upon the cardiovascular system. Very likely it is this added strain, rather than any structural damage to the circulatory apparatus, which in the majority of instances produces the cardiac symptoms. The condition is perhaps comparable to being "out of training" and the patient may never succeed in fully readjusting himself.

During the convalescent stage of fracture the appearance of cardiac arrhythmias is quite common. Usually they consist of extrasystoles, but auricular fibrillation or paroxysmal tachycardia are often observed as transient episodes, less frequently persistent. Ordinarily these complications are not serious, yet they may be very serious in the presence of advanced organic heart disease, particularly coronary sclerosis. In the latter cases they may cause anginal attacks or even precipitate sudden death if the heart is unable to tolerate the sudden excessive activity. These arrhythmias may appear immediately after the fracture or they may develop several days or even weeks later. The way in which they are produced by a fracture is a matter of speculation, but their disappearance after healing of the lesion leaves no doubt as to the certainty of a causal relationship.

Direct trauma of the heart should never be overlooked as a possible complication of fractured ribs, more particularly in the case of "steering wheel fractures." Cardiac damage is not always very obvious on examination, especially if the patient is in shock. Tears of the pericardium or rupture of pericardial or epicardial vessels may produce hemopericardium which is sometimes unnoticed until several hours after its onset, at which time the patient suddenly collapses. More often, however, the cardiac damage consists of a traumatic

myocarditis which, although it tends to disappear, may give rise to symptoms for years afterward. It is undoubtedly true that the majority of cases of traumatic myocarditis are never diagnosed because of the absence of physical signs and failure to take an electrocardiogram during the acute stage.<sup>4</sup> The patient's cardiac symptoms under the circumstances are attributed to nervousness, pleural irritation or the fractured ribs.

In connection with direct trauma, mention should be made of vascular lesions produced especially by fractures of the bones of the limbs. Occlusion of a main artery of the leg in this manner may result in gangrene, a complication which is particularly unfortunate because it is generally easy to prevent. The application of proper therapeutic measures designed to inhibit peripheral vasoconstrictor tonus of the limb vessels almost always affords sufficient increase in collateral circulation to counteract the immediate and most serious effect of the occlusion. Needless to qualify further is the possibility of seriously obstructing the limb circulation by an improperly fitted cast or splint.

A final complication of fractures which is dramatic but rare is pulmonary embolism. No cases of this type have occurred at the Philadelphia General Hospital during the past five years, which is rather surprising. The majority of pulmonary emboli do not cause death but they are always very serious. They occur occasionally after open reduction of fractures, and more frequently as a result of associated phlebitis, the appearance of which should be regarded as an indication for careful preventive therapy.

#### SUMMARY AND CONCLUSIONS

Five hundred hospitalized cases of fracture were analyzed with respect to cardiovascular complications. The mortality for the cases having a normal cardiovascular system was 1 per cent; for those having associated cardiovascular disease, 34 per

cent. The vast majority of fracture patients who died had clinical evidence of arteriosclerotic cardiovascular disease and had sustained a broken hip. Death resulted in these cases from a form of slowly progressive peripheral circulatory failure. The various ways in which fractures may cause damage or functional impairment of the cardiovascular system are discussed.

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THOUGH there are hundreds of proteins in our foods, they are all combinations of only twenty-two amino acids, each of which is essential to life.



# THE TREATMENT OF FRACTURES OF THE PATELLA\*

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A FRACTURE of the patella usually involves an interruption of the extensor apparatus of the knee. The objects of treatment are (1) to restore the complete and powerful extension of the knee and (2) to preserve or restore the normal range of flexion without leaving some irregularity of the articular surface which will tend to irritate the joint and lead to the development of a progressive arthritis after function is resumed. In addition to the above, the treatment should be so planned that the patient is subjected to as little risk as possible, that his loss of time from work is as short as possible, and that he is as comfortable as possible during his convalescence.

That the ideal method of treatment has not yet been evolved is evident from the large number described in the literature and at present used by various surgeons. It may be assumed that each of the methods now in use has been found to be satisfactory to some surgeons but not to all. In this paper I shall mention briefly a number of the methods in general use and shall describe the methods which I prefer and state why I prefer them.

In considering the treatment of a recent simple fracture of the patella the first decision required is whether or not an open operation is indicated. This decision is based upon the position of the fragments as determined by the physical examination and the roentgenogram, it being assumed that a competent surgeon and adequate facilities for aseptic surgery are available. The operation appears quite simple, but may easily go wrong and rigid ankylosis is necessary because the superficial position of the bone and its relatively poor blood supply seem to render it liable to infection. Should infection occur the knee joint is

usually involved and the surgeon faces a surgical catastrophe of considerable magnitude.

Consequently, operative fixation of a fracture of the patella is reserved for those instances in which the fracture consists of, or includes, a complete transverse lesion with the fragments separated for  $\frac{1}{8}$  inch or more. Experience has shown that such fractures do not tend to unite by bone under conservative treatment and that it matters not whether the fracture is simple transverse, mildly comminuted, or stellate in type. Not only do these fractures not unite by bone, but when there is separation of the fragments the lateral aponeurosis of the knee on either side of the patella is torn and the contraction of the quadriceps tends to pull the proximal fragment of the patella upward and the separation tends to increase with time. This results in a weak and relatively unstable extremity.

## TREATMENT OF SIMPLE FRACTURES IN WHICH THE FRAGMENTS ARE NOT SEPARATED

We will first consider the treatment of simple fractures without separation of the fragments. These may be either simple transverse or comminuted, as the number and the direction of the fracture lines apparently make little or no difference in the healing, unless the fragments are separated. As a matter of fact, an extensively comminuted fracture of the patella without separation of the fragments may be expected to unite more promptly than will a simple transverse fracture with a separation of  $\frac{1}{8}$  inch, because these comminuted fractures are the result of direct violence and as a rule the lateral aponeurosis is not torn.

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In fractures in which it has been decided not to operate it is advisable to aspirate the knee joint and apply a pressure dressing for from twenty-four to forty-eight hours, having the patient remain in bed either with or without a posterior splint. A very efficient form of pressure dressing is one made of a roll of absorbent cotton wrapped around the knee. Over this either a gauze or an elastic bandage is applied tightly. This will tend to prevent further accumulation of blood in the joint. After the excess fluid has been removed and before the pressure dressing is applied, an attempt should be made to mould the fragments by lateral and vertical digital pressure if the roentgenogram has shown slight displacement. Any irregularity of the articular surface is corrected by pressing the patella downward against the condyles of the femur. If at the end of from twenty-four to forty-eight hours there is excess fluid in the joint this should be aspirated a second time.

In aspirating the knee usually no local anesthesia is necessary. An area lateral or mesial to the superior border of the patella is painted with strong tincture of iodine. With a quick stab the needle is plunged into the knee joint, aiming at a point directly beneath the upper portion of the patella. In a hypersensitive or nervous patient the area may be infiltrated with novocaine if desired. As much blood as can be removed is then aspirated, the needle withdrawn, and a piece of sterile gauze placed over the puncture wound. I do not believe that it is necessary, or even advisable, to shave the leg or for the surgeon to scrub his hands or use rubber gloves. There is no need for the surgeon's hands to come in contact with the aspirating needle at any time during the procedure.

After the excess blood in the joint has been removed, a plaster of Paris cast is applied with the knee in a position of extension. This cast is preferably of the skin-tight walking plaster type with a small piece of felt over the patella and a thin layer of cotton around the knee joint

in order to provide for the small amount of movement which occurs at the knee. However, if one prefers, the ordinary padded plaster of Paris cast may be used. It should extend from the toes up to the groin, as it is necessary that it include as much of the thigh as possible. One should plan on leaving the cast on about six weeks. Various types of adhesive dressings have been used beneath the plaster in an attempt to bring the patellar fragments together. The usual method is to place oblique cross strips above and below; those above tend to pull the proximal fragment downward and those below tend to pull the distal fragment upward. These strips often irritate the skin beneath the cast and I do not believe they are very effective in holding the fragments together. Consequently, I no longer use them.

At the end of from four to eight weeks, depending on the fracture and the age of the patient, the plaster cast is removed and the patient may begin to bend the knee. It will be found that a relatively small amount of movement will be permitted. However, the knee should not be forced. The patient may apply hot wet compresses or dry heat to the knee two or three times daily and should exercise the quadriceps and begin to walk. At first crutches are used and then a cane; as the power in the leg returns the support is abandoned. For at least four weeks after the removal of the cast the patient is cautioned not to put his weight on the leg with the knee in a position of flexion, but to walk with the knee straight, because not only is the union not firm, but extensive atrophy has occurred in the patella and it can be refractured with relatively slight force. (Fig. 1.)

Union should be quite firm at the end of eight weeks and bony union is usually present at the end of twelve weeks. However, it may not be demonstrable in the x-ray for several months. The exercises to restore the power in the quadriceps must be kept up over a period of several months. If union occurs a practically normal knee may

be expected in from four to six months and the patient may be expected to return to occupations not involving heavy lifting or running within about three months.

fragments by wires, pins or clamps have been advised and used. I do not believe that any subcutaneous method should be used, because control of asepsis thus

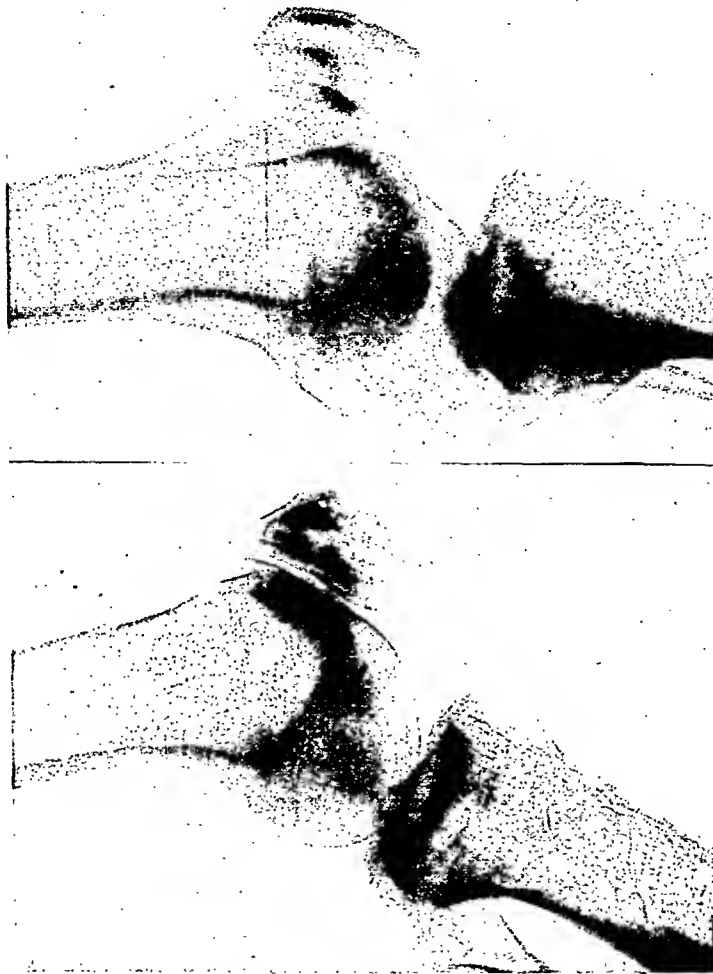


FIG. 1. Above, simple fracture of the patella without displacement. Below, same case two months later after removal of the cast. Note union, but marked atrophy of the bone.

#### TREATMENT OF SIMPLE FRACTURES OF THE PATELLA WITH SEPARATION OF THE FRAGMENTS

In these fractures operative reduction and fixation of the fragments and operative suture of the lateral aponeurosis is advised. This operation has been done for many years. That there is no method which is universally satisfactory is evidenced by the fact that there are a multitude of methods in use and by the fact that many subcutaneous methods of manipulating the

becomes more difficult and control of the fragments is less exact.

The first question to decide is—When should one operate? A considerable number, and perhaps the majority, of surgeons believe that the operation should be postponed for a week to ten days, or even longer. The reasons given are: (1) that one should wait until all tendency to hemorrhage in the joint has ceased; (2) that one should wait until a reaction has occurred in the knee joint which will render it less liable to infection; and (3) that one should

wait until a small amount of callus is thrown out from the surface of the broken bone, as it is thought that this will tend to hasten union.

I do not believe that any of the above reasons is valid. We control the hemorrhage at the time of the operation, we do not create an artificial reaction in a clean knee before operating upon it, and in other fractures we do not wait for beginning callus before reducing the fragments. The only reasons for not operating immediately are shock to the patient, which prohibits any surgical procedure beyond those necessary for saving life, and damage to the skin over the patella, which makes it impossible to control asepsis. Ordinarily, with abrasions or lacerations of the skin, if the patient is seen within a few hours of the injury, it is possible by the use of strong antiseptics and by placing the incision away from the injured area to perform the operation without undue danger of infection. On the other hand, if the patient is seen twenty-four hours or more after the injury when the superficial abrasions or lacerations have become infected, then it is extremely unwise to operate until the skin wounds have healed, and even then the skin incision should be placed as far away as possible from the recently infected area. Consequently, if the condition of the skin and the general condition of the patient permit, I believe that the patella should be operated upon as soon after the injury as it is convenient to do so, preferably immediately.

Before the operation the extremity from the mid thigh to the middle of the leg is shaved, scrubbed with soap and water, washed with alcohol and ether, and painted with strong tincture of iodine or one of the newer skin antiseptics. A tourniquet is not used and the patient is placed on the operating table with a small sand bag under the affected knee.

The next question is—What anesthetic should be used? This depends entirely upon the choice of the surgeon and upon the condition of the patient. As the bone is superficial, local anesthesia can be used

with entire satisfaction. I have employed in about half of the patients 1 per cent novocaine in the skin and  $\frac{1}{2}$  per cent in the deeper tissues. The novocaine solution contains three drops of adrenalin to the ounce, for this not only tends to control the hemorrhage, but tends also to counteract the toxic effect of the novocaine. The injection is made along the line of the proposed skin incision. The subcutaneous tissues under the skin incision are infiltrated with  $\frac{1}{2}$  per cent novocaine and about 10 c.c. of novocaine is injected well away on each side above the lateral margins of the skin incision opposite the tear in the aponeurosis. If preferred, a general anesthetic may be used.

A number of different types of incisions may be used. Most surgeons prefer either a vertical incision or a u-shaped incision which is convex downward. I prefer the u incision with a rather short flap, the bottom of the u being just below the distal end of the patella. With this incision the suture line in the skin does not lie over the fracture. The incision is carried down through the subcutaneous tissue to the lateral aponeurosis and the upper portion of the patellar ligament. The flap, including the subcutaneous tissues, is dissected upward and retracted after skin towels have been applied. This exposes the break in the bone and the tear in the aponeurosis, and through the break in the bone the knee joint is opened. The blood in the joint is evacuated and wiped out with gauze sponges. Any loose fragments of bone in the joint are removed. Likewise, loose fragments of bone which are completely detached or so nearly detached that their circulation is markedly impaired are removed.

If the fracture is a simple transverse one it will not be necessary to remove any loose fragments or to revise the edges of the fracture. However, if a comminuted fracture is present it may be advisable to remove a considerable portion of the bone and if this is done it may be necessary to revise the ends of the fragments which

remain in order to obtain as accurate a coaptation of the fracture line as possible. This can be done with rongeur forceps or

held together. The various procedures advocated will be discussed below. We use stainless steel wire of the flexible type and

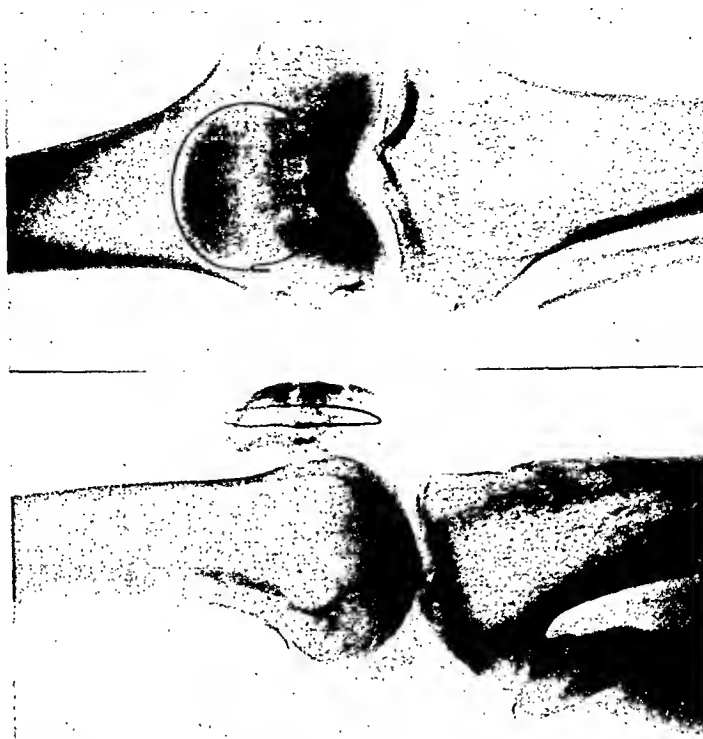


FIG. 2. Simple comminuted fracture of the patella after fixation by encircling stainless steel wire.

bone cutting forceps. It will be found that the aponeurosis on either side of the patella is torn for a variable distance outward, the length of the tear varying directly with the degree of the separation of the fragments. This tear may be quite clean cut, but is usually rather irregular, with frayed margins. Likewise, the thin aponeurosis extending over the superficial surface of the bone is torn, usually in an irregular manner. Some fringes of fibrous tissue tend to hang down into the space between the fragments. These fringes are excised because it is not possible to suture them sufficiently firmly to be of value in holding the fragments together.

It is now necessary to coapt the fragments and hold them together until union has occurred or one may excise either all or part of the patella. There is a considerable difference of opinion as to how and with what materials the fragments should be

of a strength sufficient to hold the fragment firmly together (20 or 22 gauge in a fresh fracture). This wire may be placed through or around the fragments or through the larger and around the smaller fragment, depending upon the size and shape of the fragments.

It will be noted that the distal fragment tends to be tilted in such a manner that the fractured surface tilts forward while the proximal fragment, which is usually the larger, is drawn directly upward. Consequently, in most instances a hole is drilled transversely through the larger (proximal) fragment and the wire is passed through it. The hole is made as close to the anterior surface of the patella as possible, because it is very important that the wire should not enter the knee joint, and also because it is important that it tend to pull the superficial or anterior margins of the fracture line together as this assures an

accurate coaptation of the articular surface. Then the wire is brought down through the lateral aponeurosis close to the

and the lower up by sharp toothed retractors placed in the proximal and distal ends of each, respectively, so that the fractured



FIG. 3. A bilateral fracture of the patella wired with soft iron wire. No trouble with the wire after seven years. Both knees apparently normal.

margins of the patella, and passed either through another transverse drill hole in the distal fragment or, if this fragment is quite small and comminuted, through the patellar ligament just below this fragment.

The two fragments are then accurately approximated, the upper being pulled down

surfaces are pressed together. Then the wire is pulled taut, twisted together and cut off. The twisted end is bent downward and inward and buried in the tissues alongside the lower pole of the patella. The lateral aponeurosis is now sutured with mattress sutures of D silk. It is to be noted

that the patella is first wired firmly together before the aponeurosis is sutured. This is done for two reasons: (1) because

fers, however, and if the fragments have been securely wired together, no immobilization is necessary. An elastic bandage



FIG. 4. Compound comminuted fracture of the patella debrided and wired after removal of about half of the bone. Uneventful recovery. Marked atrophy of lower fragment and questionable union in the x-ray.

after the patella is wired the aponeurosis can be sutured more easily and without undue tension; and (2) because the accurate apposition of the patellar fragments, which is important if one is to prevent postoperative arthritis of the knee, can be performed more readily before the aponeurosis is sutured. The mattress sutures take small bites in the aponeurosis on either side; usually about four such sutures are placed on each side of the patella. The subcutaneous tissues are then closed with fine silk and the skin is sutured with silk.

Postoperatively the knee may be immobilized or not, depending upon the choice of the surgeon and upon the security with which the fragments of the patella have been fixed by the wire. The patient is more comfortable if it is immobilized in a cylinder plaster cast for about ten days, at the end of which time the cast is taken off, the sutures are removed and an elastic bandage is applied. The patient is encouraged to exercise the knee. If one pre-

is applied over the dry dressing and the patient may begin to move the knee within three or four days after the operation. The sutures are removed at the usual time and the patient may be up on crutches at the end of two weeks. He is encouraged to exercise the knee, but is advised not to put his weight upon the extremity with the knee flexed. At the end of eight weeks union should be firm and almost normal motion in the knee should be present. The patient may begin light work within about four weeks, but should use a cane for at least eight weeks after the operation.

The stainless steel wire is used because the fragments can be fixed more firmly with wire than with any absorbable material or with silk. The stainless steel wire can be tolerated indefinitely by the tissues and has not, in my experience, caused trouble. There has not even been a great deal of difficulty with the wire in the two instances which I have seen in which postoperative infection of the wound occurred. The exact



manner of placing the wire depends upon the form and size of the fragments found at the operation. In some instances the

to all intents and purposes normal. The patient is now over 60 years of age and leads a very active life.

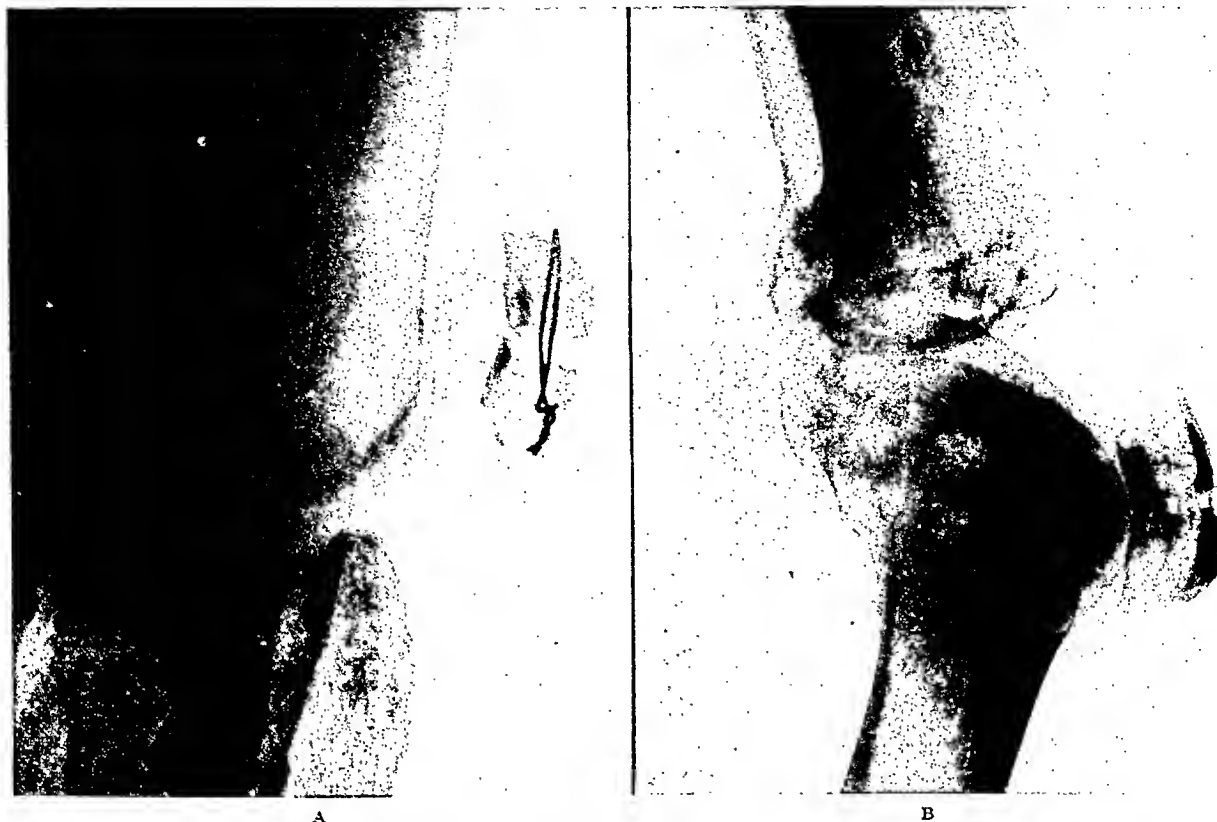


FIG. 5. A, simple fracture of the patella wired. Followed by postoperative infection. Wire left in until patella had united. B, same case after removal of the wire. Stable painless knee with about 70 degrees of movement six months after injury.

wire is placed through both fragments, in some instances through one fragment and around the other, and in other instances around both fragments. (Figs. 2, 3, 4 and 5.) When one or both fragments are encircled with wire, this is placed through or just beneath the aponeurosis and care is taken that the wire does not lie in the joint cavity at any point. This is accomplished by threading the wire on a large curved needle, the point of which is brought out through the superficial fibers of the aponeurosis as often as is necessary to maintain the superficial position of the wire.

Before flexible stainless steel wire was obtainable I used soft iron wire (stove pipe wire) and found that even this type of wire is tolerated by the tissues over many years without difficulty. The bilateral fracture illustrated in Figures 4 and 5 was fixed with soft iron wire in 1932 and has caused no difficulty up to this time, the knees being

My objection to the use of fascia, chromic catgut, kangaroo tendon or silk for the fixation of bone fragments is that none of these can be relied upon to fix the fragments together as firmly as does wire. A further objection to the use of fascia is that it unnecessarily complicates the procedure. Likewise, I believe that there is more danger of postoperative infection after the use of fascia or heavy absorbable sutures, such as chromic catgut or kangaroo tendon, than there is after the use of a slender inert stainless steel wire. If wire were not available, I would choose heavy braided silk or linen and encircle both fragments, because there is a tendency for silk to be cut by the edge of the bone when it is passed through a drill hole and tied under tension. The objection which many men have to leaving non-absorbable material, such as wire or metal screws or plates, in bone will, I believe, disappear as the use of stainless

steel becomes more general. Other forms of fixation, such as screws or bone grafts are less effective and render the operation

cence and maintains a better function in the knee.

It is probable that in an instance such as



FIG. 6. Old fracture of the patella. Lengthening of quadriceps and excision of ends of fragments necessary before wiring.



FIG. 7. Avulsion of patellar ligament sutured with heavy braided silk. Uneventful recovery.

much more difficult. Obviously, anything that can be done to simplify the operation and the postoperative care should be encouraged. Especially to be condemned is the method of suturing only the lateral aponeurosis and not wiring or tying the bone fragments together. This procedure demands prolonged immobilization and invites nonunion. I believe that the importance of suturing the aponeurosis has been overemphasized. It is good surgery to suture the aponeurosis after the fragments have been wired together, but it is more important to coapt the bone fragments and hold them together until union has occurred.

The question of excision of the lower fragment as advocated by Thomson<sup>1</sup> and Blodgett and Fairchild,<sup>2</sup> or of excision of the entire patella as advocated by Brooke,<sup>3</sup> Tippet,<sup>4</sup> and Blodgett and Fairchild<sup>2</sup> is one which may be given thought. Thomson excises the lesser of the two fragments, usually the lower, and fixes the patellar ligament or quadriceps tendon to the remaining fragment, thus eliminating the necessity of union by bone. He believes that this procedure shortens the convales-

that illustrated in Figure 4 it would have been wise to excise the lower fragment and suture the patellar ligament to the upper fragment with silk, because, while clinically there was union, the x-ray did not show union five months after the accident. The patient, being a compensation case, claimed that the fragments were not united. His doctors claimed that it would be necessary to remove the wire and the lower fragment, although there was no clinical indication for the removal of either and the knee was apparently normal with the exception of weakness from quadriceps atrophy. It is thus evident that the presence of wire in the tissues is slightly objectionable in compensation cases. However, I do not believe that this objection is of sufficient importance to bar its use when its other advantages are considered. This particular case was a severe compound comminuted fracture with fragments of a broken emery wheel in the tissues.

Concerning the question of the removal of the entire patella, I have not performed this operation for fracture of the patella, although I have done it for ankylosis of the patella to the femur. However, the results and the experimental observations of Brooke<sup>3</sup> are very convincing and I see no reason why it should not be done, espe-

cially in severely comminuted fractures with separation of the fragments. On the other hand, it is quite a radical procedure and I do not believe that it will be generally adopted as a treatment for uncomplicated fractures of the patella.

#### COMPOUND FRACTURES OF THE PATELLA

A compound fracture of the patella is similar to a compound fracture of any other bone plus an opening into the knee joint and if it is seen early (within six to ten hours after the accident) it should be thoroughly debrided and sutured. The debridement is carried out according to standard principles, excising the skin edges, removing all foreign matter and loose fragments of bone and then washing out the wound and washing out the knee joint with a large amount of warm normal salt solution. Any devitalized tissue is excised. The fragments of the patella are then fixed with stainless steel wire just as described above for a simple fracture and the aponeurosis is sutured, either with silk or chromic catgut, according to the preference of the surgeon. The skin and subcutaneous tissues are sutured in one layer with interrupted silkworm gut sutures and a small rubber drain is inserted on either side. This drain may be placed down to the capsule or may extend into the knee joint, depending upon whether one believes that he has performed an adequate debridement sufficiently soon after the injury to be reasonably sure that the knee will not become infected. This drain is removed at the end of forty-eight hours and the fracture is treated as a simple fracture. (Fig. 4.) After suture of the patella for a compound fracture the knee is immobilized in a well-padded plaster cast which extends from the toes to the groin and vaseline gauze is placed over the suture line to permit drainage, the skin being sutured rather loosely. The knee is immobilized in a cast because I believe that this is an important factor in the prevention of infection. Sulfanilamide in doses of 15 gr. every four hours should also be given as a

prophylactic against infection in severe compound fractures.

If there should be evidence of infection, as indicated by a rise in temperature, a rise in the pulse or an unusual amount of pain in the wound, the cast should be bivalved and the wound inspected immediately. Sufficient skin sutures should be removed to determine whether or not the infection is in the superficial tissues or in the knee joint. If the infection is deep, the joint should be opened freely and a large wet dressing applied, at the same time maintaining immobilization. I have not found that the presence of the wire was a detrimental factor in the early days of an infected wound and believe that its immobilizing effect is a distinct benefit. In such wounds, however, it is usual to remove the wire after the infection has quieted down, but before it has healed.

In very severe fulminating infections it is advisable to remove the wire, separate the fragments, remove all loose fragments and, if necessary, remove the patella. However, this has not yet been necessary in my experience.

If the infection is found to be due to a streptococcus or to a gas bacillus a massive dose of sulfanilamide (90 gr.) should be given immediately and should be followed by 15 gr. every four hours. This is continued until the patient's temperature has dropped to a satisfactory level and the infection has subsided, or until it is necessary to stop the drug because of an idiosyncrasy. In addition to the chemotherapy the wound should be treated surgically as described above.

Throughout the process of the treatment of the knee for an infection due to a compound fracture of the patella or due to a postoperative infection of a patella which has been sutured, the knee should be kept in a straight position and no attempt should be made to move it until the infection has subsided and the deeper tissues have healed. Usually it will be found that this will result in a localization of the infection in the front of the knee joint. After the

infection has subsided and the wounds have healed there will be a slow, but progressive return of function and in most instances the range of movement will increase over a period of months (Fig. 5), although occasionally bony ankylosis at the knee may occur.

#### OLD FRACTURES OF THE PATELLA

In old fractures of the patella the fragments are usually widely separated and the proximal fragment is maintained in its abnormal position by contracture of the quadriceps muscle. In addition to the above, the ends of the fragments are sealed over by scar tissue. Likewise, there is a thin layer of scar tissue bridging the space left by the tear in the lateral aponeurosis on either side of the patella. In treating such a lesion it is necessary to excise the scar tissue between the torn ends of the aponeurosis and to excise the ends of each fragment in order that fresh bleeding bone may be exposed and opposed. After this has been done it will usually be found that it is not possible to pull the two fragments together. Not only is the proximal fragment displaced and held up on the thigh, but the distal fragment is displaced downward.

In order to coapt the two freshened bone surfaces it will usually be necessary to lengthen the quadriceps tendon. This can be done by the z method or by the tendon plastic method of Bennett in which a long tongue of the quadriceps tendon is cut free and slipped downward and then sutured at a lower level by suturing the muscle fibers to it on either side. However, in performing this operation it is to be noted that lengthening of the central tendon itself will not permit downward displacement of the patella, nor will it permit flexion in a knee which has become fixed in extension by contractures. The real fixation of the patella upward on the femur is not due to the quadriceps tendon, but is due to the shortening of the tissues on either side of the upper pole of the patella which bind it to the femur just above the condyles. These are largely portions of the vastus internus

and externus, and these fibers must be cut across, opening the quadriceps bursa of the knee joint and freeing the upper pole of the patella on either side. Then the upper fragment can be pulled downward, swinging by a pedicle of tissue on either side and carrying with it the freed quadriceps tendon above. This will leave a dead space or gap 1 to 2 inches wide in the quadriceps muscle on either side at the upper pole of the patella. I have usually left the space open, but occasionally I have partly obliterated it by transplantation of muscle fibers. It apparently takes care of itself and has not caused any trouble, except worry, until the danger of infection is over.

After the quadriceps apparatus has been lengthened to such a degree that the upper fragment can be brought downward, the two fragments are held together with sharp toothed retractors and are fixed with a wire loop, just as though one were dealing with a fresh simple fracture. Then the aponeurosis on either side is sutured with silk and the wound is closed in the usual manner. For this operation a long anterior incision is used, the incision curving inward around the mesial aspect of the patella, extending down to the tibial tubercle and as far upward on the thigh as is necessary. After the operation it is advisable to immobilize the extremity in a plaster of Paris cast with as much flexion as can be obtained without undue tension on the fragments. The immobilization is continued for from two to four weeks, depending upon the postoperative course. (Fig. 6.)

#### TREATMENT OF AVULSION OF THE QUADRICEPS TENDON OR OF THE PATELLAR LIGAMENT

In these instances the tear is usually close to the upper or lower pole of the patella and not infrequently a small amount of bone is torn off with the tendon. It is not practicable to fix the tendon to the bone with wire because the wire pulls through the vertical tendon fibers and becomes loose and when the wire becomes loose it acts as an irritant. Consequently,

for these injuries I use heavy braided silk sutures, weaving the silk into the tendon and leaving four strands of silk projecting from the torn end of the tendon. Then two drill holes are made in the patella, passing vertically upward or downward through the bone, keeping well away from the articular surface. The heavy silk is passed through these drill holes and tied firmly at the opposite pole of the bone. The torn aponeurosis is sutured with silk in the usual manner and the subcutaneous tissues and skin are closed with silk.

Postoperatively the knee is immobilized in a plaster of Paris cast for four weeks. It is not felt that the silk is strong enough to permit free use of the knee before this time, nor is it felt that the union between the torn tendon and the bone will be sufficiently strong to permit freedom of the knee without danger that the sutures may be torn loose. At the end of this time the cast is removed and the patient is encouraged to begin exercising the knee and to bear weight upon it with the knee in the straight position. He may walk with crutches or with a cane, but is cautioned against putting his weight on the flexed knee. A very strong and useful knee may be expected within eight to twelve weeks and

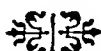
a practically normal knee within about six months. (Fig. 7.)

#### SUMMARY

Simple fractures of the patella without separation of the fragments are treated by immobilization in a plaster of Paris cast. If the fragments are separated they are reduced by open operation and tied together. A loop of stainless steel wire is preferred to any other type of suture. The tear in the lateral aponeurosis is sutured with D silk. Avulsions of the quadriceps tendon or of the patellar ligament are repaired by heavy silk which is passed through two drill holes in the patella and tied at the opposite pole of the bone. The management of compound fractures, of infected fractures and of old fractures of the patella is described.

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# FRACTURES OF THE KNEE

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PRACTICALLY every fracture is an individual problem. For this reason it is difficult to standardize methods of treatment. Each fracture of the knee is considered a unique problem to be treated by that method offering the best result. The requirements for obtaining such a result are:

1. *Smoothness of the Joint Surfaces.* This is a requirement of great importance. Roughened weight-bearing joint surfaces are most likely to become permanently painful and disabling. Anatomic position, though not so essential in the shaft of a bone, is important in fractures within the joint. Accurate replacement of fragments to obtain smooth joint surfaces is essential for good function.

2. *Length.* Should be equal to that of the opposite leg.

3. *Good alignment* to restore as nearly as possible normal mechanics of the lower extremity so as to have neither a knock-knee nor a bow leg.

(The good knee serves as a guide for the proper angle between the tibia and the femur.)

4. *Good apposition* must be better than one might be willing to accept in the muscular area of an extremity. At the knee the bone is entirely superficial, and a defect unnoticed in the mid shaft of a bone would be conspicuous in the head of the tibia or in either condyle.

There are certain obligations due the patient from the beginning of treatment. His pain should be relieved as quickly as possible. Immediate splinting in whatever position is most comfortable, plus a narcotic, may be all that is necessary. If not, the fracture can be infiltrated with 10 to 20 c.c. of 2 per cent novocaine before the patient is transferred to the hospital, provided of course that the skin is in good

condition. Careful handling of the leg is not only gratifying to the injured person, but will sometimes prevent a sharp edge of bone from piercing the skin and making a compound wound.

Upon arrival at the hospital the patient is immediately taken to the operating room where he is transferred to a wheel carriage. X-rays are made there with a portable apparatus to minimize movement of the leg. The x-rays are studied and plans are made for reduction of the fracture. If it appears that manipulation or skeletal traction and plaster cast fixation would accomplish a permanent and satisfactory reduction, preparations are made while the patient is given a general examination, including urinalysis and blood studies. A general anesthesia is given the patient while he is still on the wheel carriage and he is then placed on the fracture table. If good position of the bones is not obtained, an open reduction and internal fixation with rustless steel wire, bands, screws or nails may be done immediately if the patient's general condition will permit. This can usually be done subperiosteally or without extending the incision into the knee joint.

Should there be a compound wound, it is cleansed, and closed or drained depending upon the number of hours that have passed since the time of injury. Gas bacillus and antitetanic serum are given. If there be shock or complicating injuries, plaster splints (posterior, lateral and medial) are applied from the toes to the groin and the fracture may be treated any time within the following ten days. When there is a marked displacement of the bones into the popliteal space, pressure on the blood vessels and nerves must be immediately relieved. It is important to know the condition of the circulation and of the nerves to the leg and foot in every fracture

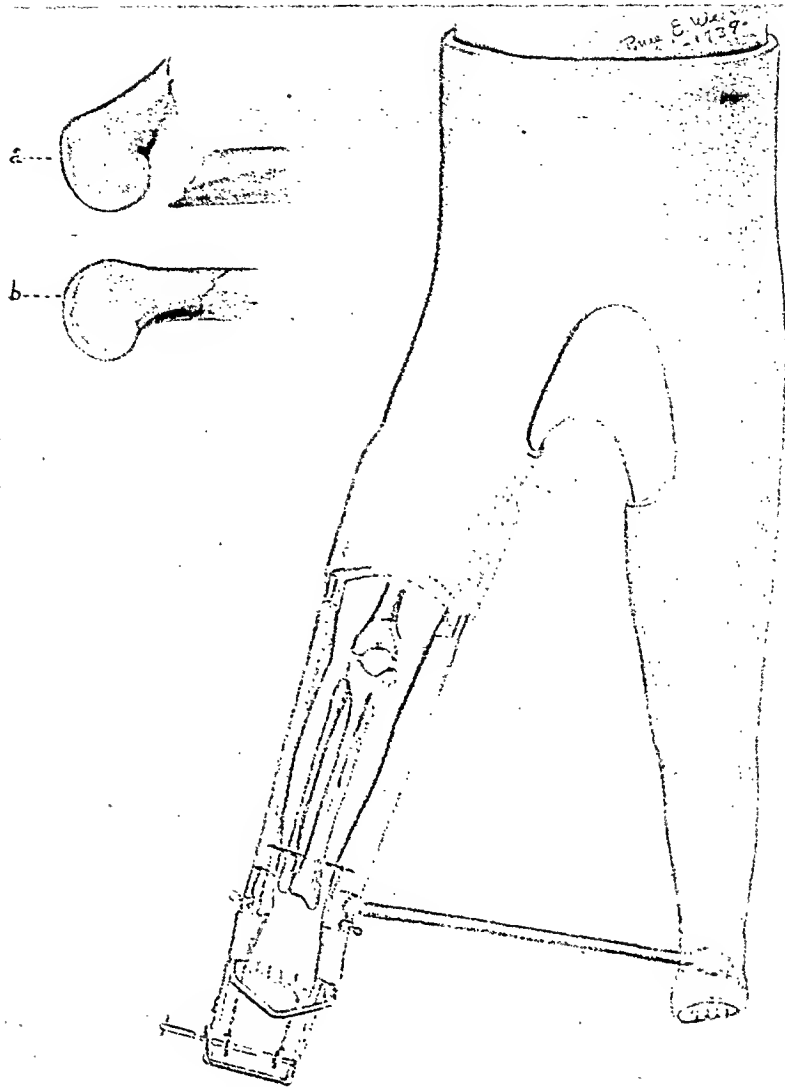


FIG. 1. Supracondylar fracture of femur reduced by skeletal plaster traction. "The principle of this apparatus is that while traction is applied to the fractured extremity, countertraction is being applied to the sole of the opposite foot." It is applied as follows:

"A suit of stockinet is put on. Felt padding should line the back and sides of the body and pelvic portion of the cast. A double spica cast is applied, extending from mid-abdomen to the toes of the unaffected leg and down the injured leg to a point above the fracture. The unaffected leg is held in a position parallel with the midline of the body to facilitate turning the patient from back to side and abdomen. The foot of the unaffected side is held in a normal weight-bearing position, i.e., with the sole of the foot at right angle to the leg. This foot should be well padded with sheet wadding. Felt has been found unsatisfactory for this purpose."

General anesthesia is then given and a Steinmann pin is inserted with an electric drill through the lower end of the tibia. A traction ratchet is attached to the cast as shown; the Steinmann pin is connected with the ratchet with small size brass chain. Traction is obtained by winding the chain on the ratchet.

Precautions: "The cast should be well padded, especially over the lateral surface of the hip and pelvis of the injured side, as considerable pressure is exerted on this surface when traction is applied. The upper end of the inner bar of the traction splint should not be closer than a hand's breadth to the perineum. The reason for this precaution is that as the injured extremity is pulled downward by the traction, the perineum might come in contact with the upper end of the bar and cause serious pressure. For the same reason, the cast should be trimmed at least a hand's breadth below the perineum."\*

Note: A valuable method also in treating fractures of the shaft of femur in children. In small children adhesive tape on the leg is substituted for the Steinmann pin.

\* THORNTON, LAWSON, *Piedmont Hosp. Bull.*, May and June, 1925.



of the knee. Pressure on the peroneal nerve by a spicule of bone from the head or neck of the fibula is another complication requir-

as to necessitate an amputation on the tenth day. The popliteal artery was found to be torn and thrombosed.

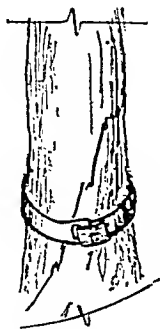


FIG. 2. Oblique supracondylar fracture of the femur may be satisfactorily held with a Parham band placed subperiosteally around the bones through a small incision on each side of the knee.



FIG. 3. Fracture of the patella. X-ray before operation.

ing immediate correction, possibly by open reduction. In one instance where the knee had been violently twisted in an automobile accident, the circulation was so inadequate



FIG. 4. Fracture of patella. X-ray after open reduction held with a circular rustless steel wire.

The accompanying drawings and x-rays illustrate some of the types of fractures and methods of treatment. Plaster cast fixation is used in all cases because it provides the best chance for maintaining the reduction and a maximum of comfort and immobilization. The patient is given freedom of the bed, wheel carriage or wheel chair. Steinmann pins are preferable to Kirschner wire because the unnecessary bulk and weight of the Kirschner clamps are eliminated.

After reduction the leg is carefully watched for swelling and the cast is split and spread whenever necessary. The knee is always held in extension with possibly 5 or 10 degrees of flexion; the foot is always held in midposition and at a right angle to the leg. When the x-ray shows that there is sufficient union (eight to ten weeks) the cast is removed and passive and active motion of the knee is begun. During the first few days the patient is kept in bed for continuous application of heat. Then he is allowed to walk on crutches, with or with-

out a brace, depending on the type of fracture or the degree of union. Each day for the following month or more the patient the period of disability but is an excellent means of approximating normal knee function.

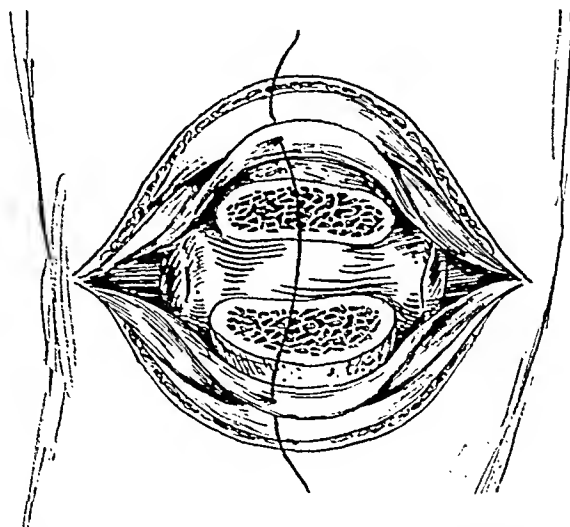


FIG. 5. Open reduction of fracture of patella. Separated patella exposed. The first interrupted chromic catgut suture in capsule and anterior fascia has been placed.

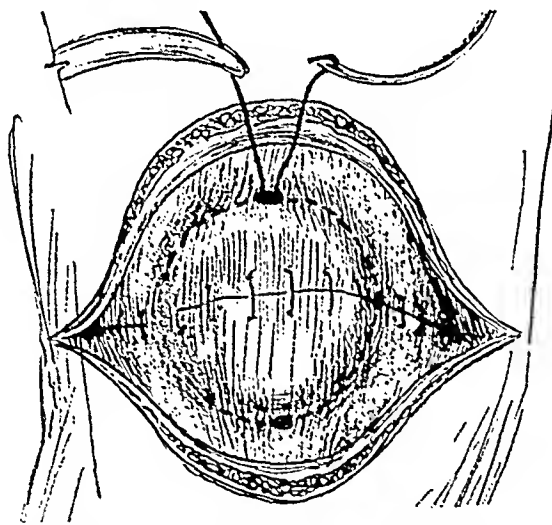


FIG. 6. Operation for fracture of the patella completed. The fracture has been reduced and held with a rustless steel wire encircling the periphery of the bone (dotted). The two ends of the wire are shown just before twisting and cutting the knot short. The capsule and fascia have been closed with interrupted chromic catgut sutures.

is under the care and direction of an expert physiotherapist. He is given baking, massage, active and passive knee motion, exercises and development of the muscles with the Morton Smart galvanic current machine. Such continuous and persistent treatment is valuable and not only shortens

It is usually true that in fractures of the knee neither the lateral nor the crucial ligaments are ruptured. The reason probably is that the bone "gives way" before the ligaments can be torn. Even with a tearing of one of these ligaments, satisfactory healing may occur during the weeks



A



B

FIG. 7. X-ray of split fracture of the head of the tibia before and after reduction by method shown in Figure 8. (From Thornton, in "Cyclopedia of Medicine," F. A. Davis Co., Vol. v, 1932.)

of immobilization in a plaster cast, resulting in a stable joint. In one of the accompanying illustrated cases there was a complete rupture of the patellar tendon that was not discovered until incision was made for open reduction of the comminuted fracture of the head of the tibia.

Should the knee joint be unstable as result of ligament relaxation following healing and after the muscles have been improved by physiotherapy, surgical repair of lateral or crucial ligaments may be necessary.

### CASE REPORTS

*Fracture of Patella with Wide Separation.* Mr. S., age 44 years. (Figs. 3-6.) June 12, 1932, the right patella was fractured in an automobile accident. The patella struck the instrument board when patient was thrown forward by the sudden stopping of the car.

Operation was done June 13. A transverse incision throughout the anterior half of circumference of the knee exposed a badly torn capsule and the shattered patella. The torn synovial membrane was closed with fine catgut. Four deep chromic catgut sutures were taken on each side of patella to approximate the torn capsule and fascia. A removable rustless wire was threaded around the fragments of the patella, as shown in the x-ray. Fine plain catgut was used to approximate the superficial layers of fascia and fat. The leg was immobilized in a plaster cast extending from toes to upper thigh.

On July 11, 1932, the cast was removed and physiotherapy and walking with crutches were begun.

Result: July 27, 1932 the patient was dismissed with normal function.

*Fracture of Head of Tibia.* Mr. M. J., age 49 years. (Figs. 7 and 8.) On September 22, 1930, the bumper of automobile struck his leg below the knee. X-ray (Fig. 7) showed displacement of fragments involving the knee joint. The fracture was treated in the following manner:

Reduction: "Under general anesthesia, a Steinmann pin (Fig. 8a) was placed through the femur just above the condyles, and another Steinmann pin (a') through the heel. A plaster cast (b) was applied, extending from the groin

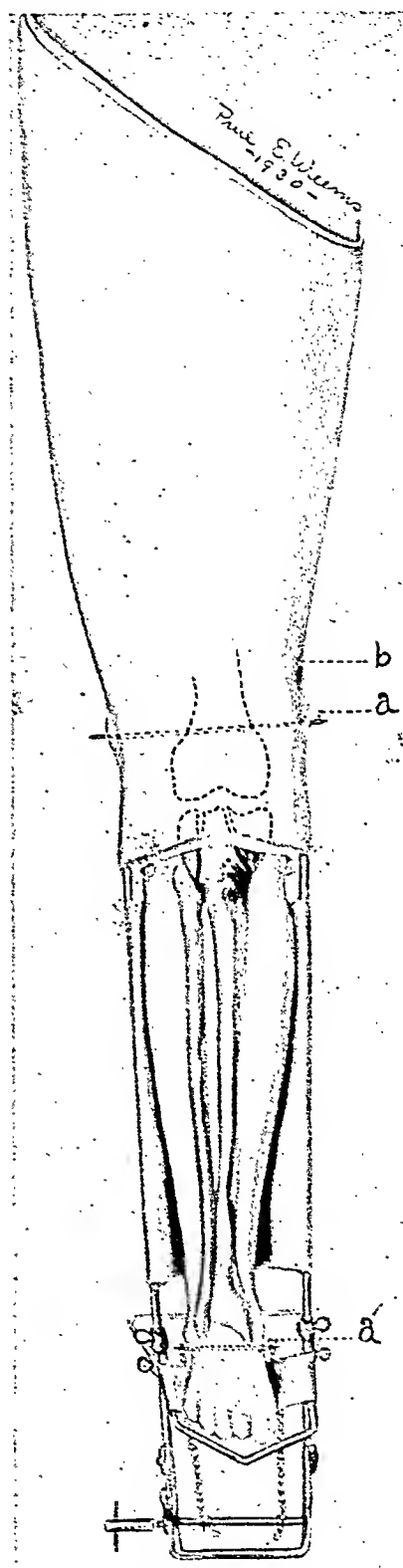


FIG. 8. Drawing illustrating method of reduction of split fracture of head of tibia. The same principle of fixed skeletal traction shown in Figure 1 is used. The Steinmann pin through lower femur (a) is used here in place of countertraction on the sole of the opposite foot as in Figure 1. (From Thornton, in "Cyclopedia of Medicine," F. A. Davis Co., Vol. v, 1932.)

to a point above the ankle. The ends of the Steinmann pin, through the femur, were incorporated in the cast. A ratchet traction

apparatus, the cast and pins were removed and a new plaster cast applied, extending from upper thigh to the toes, to be worn for two

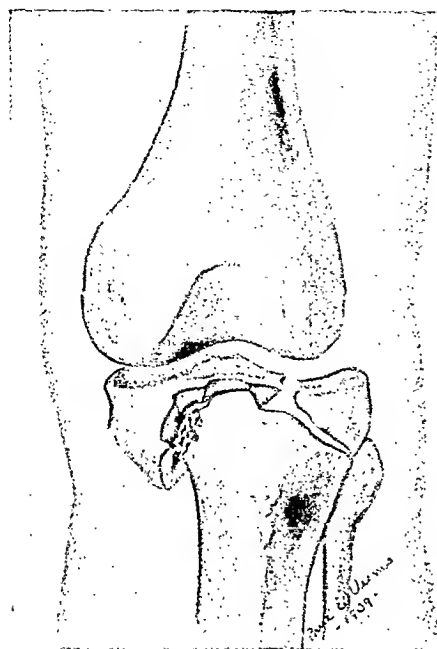


FIG. 9.

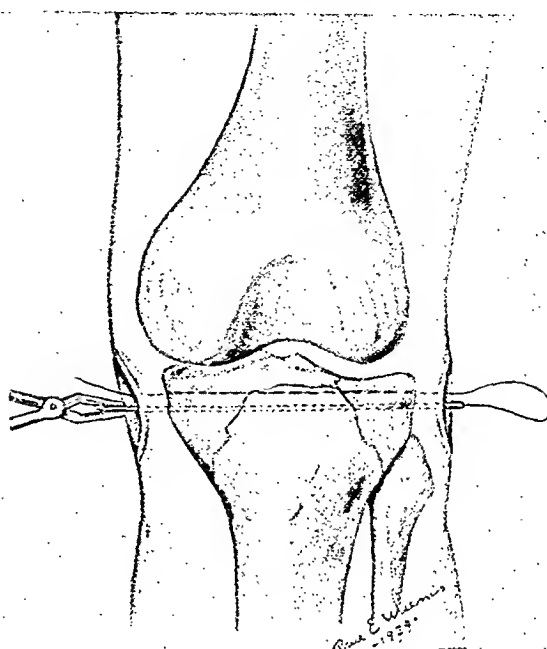


FIG. 10.

FIG. 9. Drawing from the x-ray of a comminuted fracture of the head of the tibia.

FIG. 10. X-ray of tibia shown in Figure 9 after reduction by the following method: The fracture was reduced with traction and manipulation. The bones were held in place with a through and through rustless steel wire suture passed through holes in the bone made with a drill as shown. The posterior end of the drill is hollow and serves as a wire carrier. A small incision is made on each side of the tibia near the knee joint articulation. The drill as shown is making the return passage close to the point of original entrance.

apparatus was attached to the lower end of the cast by means of plaster bandages. Two small

more weeks. It was then removed and motion and physiotherapy were begun."

On October 17, 1930, the cast and Steinmann pin were removed. The pin wounds were clean. A new cast was applied. This was removed November 15, and physiotherapy, heat, massage, and motion were given.

On November 24, 1930, the patient was dismissed, walking with crutches and possessing 60 degrees motion. In June, 1932, he had 95 degrees knee motion, no lameness. He was comfortable and had no deformity.

**Fracture of Head of Tibia.** Mr. W. M. C., age 21 years. (Figs. 9, 10 and 11.) On May 1, 1932, three days after injury by a farm tractor, open reduction was done. Fragments were replaced by tightening strong, rustless steel wire threaded through channels drilled through the fragments. Plaster cast immobilization was necessary for six weeks. Normal range of motion of the knee, with normal function and no pain, resulted.

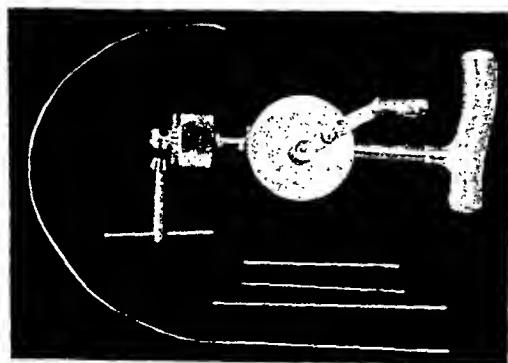


FIG. 11. The drill, drill points and wire used in the operation of Fig. 10.

brass chains connected the heel pin with the ratchet windlass. When the windlass was wound, traction was applied through the heel pin, and countertraction by the pin through the femur. After four weeks in this traction

*Comminuted Fracture of Head of Tibia with Rupture of Patellar Tendon.* Mrs. F. Y., age, 35 years. (Figs. 12 and 13.) On November 3,

joint motion with daily physiotherapy, followed by walking with crutches, physiotherapy being continued.



FIG. 12. X-ray of comminuted fracture of head of tibia.



FIG. 13. X-ray of tibia shown in Figure 12 following open reduction and fixation with two wire sutures.

1938 the head of the tibia was fractured into knee joint when the patient hit her leg below the knee against a log while hiking. X-ray showed considerable displacement and roughening of the floor of the joint. Traction and manipulation under general anesthesia did not give a satisfactory reduction.

Operation was done November 11, 1938. Through a midline vertical incision, close to the tibial tubercle and without exposure of the joint, the bones were levered into good position and held with two circular rustless steel wires. *The patellar tendon was found to be completely ruptured* and was sutured with chromic catgut. A plaster cast was applied from toes to groin. The leg was immobilized for seven and one-half weeks. Patient then had one week in bed for

On February 13, 1939, she walked without support, and had 75 degrees of comfortable knee motion. The maximum degree of motion has not yet been obtained. Continued improvement is expected.

*Fracture of Patella (Old) with Contracted Quadriceps Tendon.* Mr. C. B., age 20 years. (Figs. 14 and 15.) The left patella was fractured on July 10, 1938 in an automobile accident. The patient was unable to extend leg. X-ray showed fracture with about a 2 inch separation of the fragments.

At operation, on November 21, 1938, the space between the separated fragments was filled with dense scar tissue. After this was excised and the upper fragment with its

quadriceps tendon freed of adhesions, approximation of the fracture was still impossible on account of the contracted quadriceps tendon.

worn for five weeks. The patient was instructed in development of knee motion.

On February 15, 1939, he was walking well

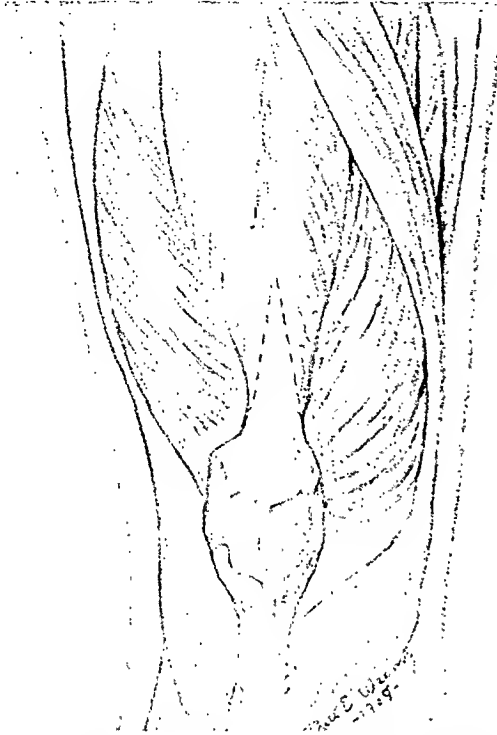


FIG. 14. Drawing of condition found at operation of fractured patella four months after injury. Operative correction in Figure 15.

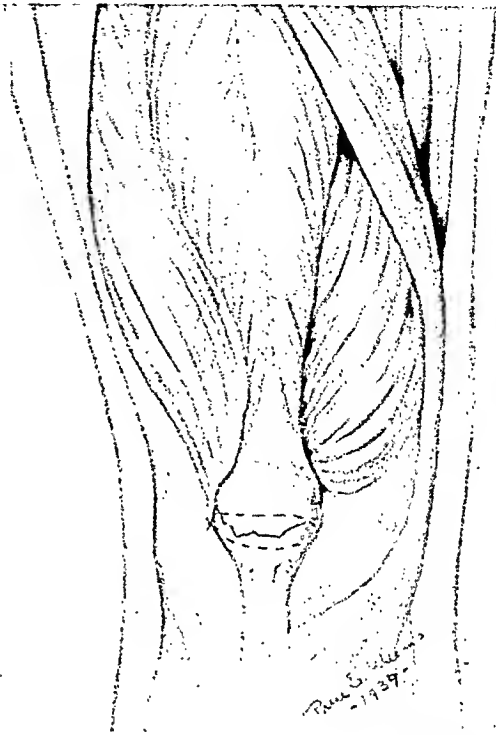


FIG. 15. Drawing of completed operation for condition shown in Figure 14. It was necessary to lengthen the quadriceps tendon for approximation of the separated patella fracture.



FIG. 16. Detail of moulding a leg plaster cast about the tibial tubercle to prevent rotation.

The tendon was lengthened and resutured and the patella wired together with a circular rustless steel wire. Plaster cast, knee extended, was

and comfortably. The knee could be bent to 90 degrees and was possessed of good power of extension.





# EXTRA-ARTICULAR FUSION OF THE HIP JOINT FOR TUBERCULOSIS

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**T**UBERCULOSIS of the hip is most unfavorable to the occurrence of intra-articular arthrodesis, or fusion, either as a spontaneous event, or by operative measures. The reasons for this are obvious: (1) inhibition of osteogenesis by the tubercle bacillus; and (2) the anatomical contours of the joint cause recession of bone surfaces from each other as bone destruction progresses, or following intra-articular removal of bone by the surgeon for arthrodesis purposes. The ball and socket contour of this joint causes the femoral head to be smaller and the acetabulum to become larger from pathologic erosion or surgical removal of the joint surfaces. Again, because of the anatomy and mechanical relationships of the hip and pelvis, as extensive destruction progresses, the diseased bony surfaces of the femur and pelvis are prevented from approximating because of impingement of the inside of the great trochanter against soft parts at and above the rim of the acetabulum. Since the tubercle bacilli inhibit active osteogenesis which would normally take place, dead spaces are left between the bony elements, and spontaneous ankylosis and cure become improbable.

Bracing in cases of extensive destruction with spaces filled with caseation has, for the same reason, been signally unsuccessful. This inhibition to healing has been so striking that many cases have been seen where complete destruction of the head and neck of the femur has occurred, so that x-ray studies show a mere spike remnant of the head and neck displaced into the acetabulum which has become markedly enlarged to over double its normal size. This enormous cavity is filled with caseous material with no possible chance of spon-

taneous fusion even after ten years or more of conservative treatment. Such cases are associated with 3 to 4 inches of shortening and a limb including the foot that is one-half to two-thirds the volume of the other. The knee is markedly "knock-kneed" with laxity or almost complete destruction of the lateral ligaments from the constant lateral pressure of braces or splints over so many years. (Figs. 1, 2 and 3.)

The contrasting result when extra-articular arthrodesis has been done early is great. A normal knee, with good function, is present, and the limb is only slightly atrophied, with little shortening. The success of operative treatment has been so spectacular when compared with prolonged conservative treatment that it is not strange that the pendulum has swung so strongly toward early operation in tuberculosis of the hip, as well as of the spine and certain other joints.

Extra-articular arthrodesis, first used by the author in 1913, and described in 1919, has proved most satisfactory. By strongly bridging the joint with a tibial, femoral or iliac graft or grafts mortised into the bony elements on both sides of the joint, complete fixation is secured. The immobilizing influence of extra-articular union of the femur to the pelvis makes it unnecessary to enter the infected area. (Fig. 4.)

This operation has now been employed by the author for twenty-six years with very satisfactory clinical and functional results.

In the *Annals of Surgery* (March, 1929) he reported in detail the results obtained in thirty-one cases, and in the past ten years, forty-seven equally successful cases have been accumulated.

## Albee—Hip Joint Fusion

X-rays taken a few months after operation show the grafts firmly in place, with the degree of telescoping of head and neck into the pelvis from joint destruction and those taken several years later (even or adduction and flexion deformity, the

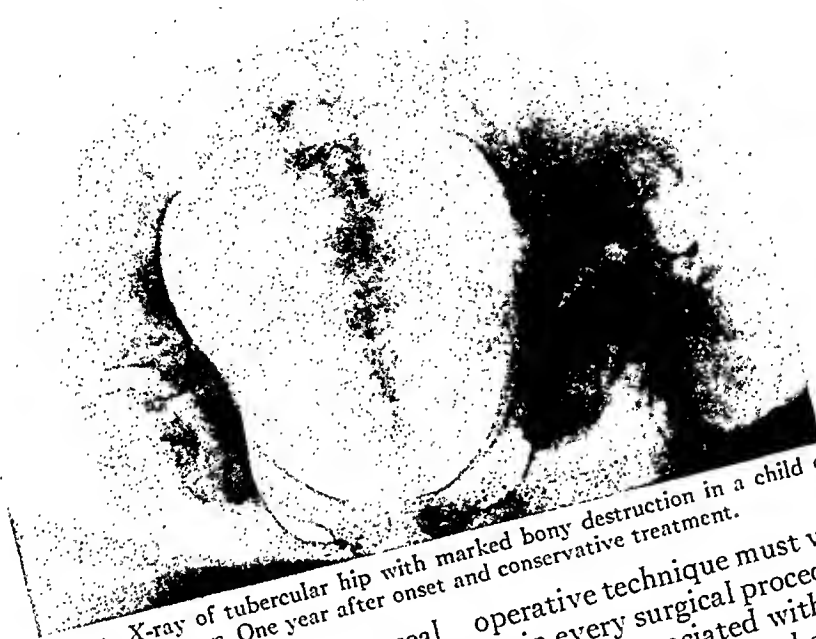


FIG. 1. X-ray of tubercular hip with marked bony destruction in a child of 8 years. One year after onset and conservative treatment.

twenty-six years after operation) reveal marked proliferation of the grafts, and illustrate well the strong bridging support which this type of extra-articular arthrodesis affords. (Fig. 5.)

#### FOUR VARIATIONS OF TECHNIQUE ADAPTED TO VARYING DEGREES OF DESTRUCTION

From his experience with extra-articular arthrodesis of the hip during the past twenty-six years, the author has been convinced more and more that it is distinctly advantageous to the surgeon to have more than one type of operation to select from in meeting the variety of mechanical requirements. Extra-articular arthrodesis in active tuberculosis is best brought about between the great trochanter on one side of the joint and the side of the ilium just above the rim of the pelvis on the other, and since the proximity of the trochanter to the side of the pelvis and the rim of the acetabulum varies widely in accordance

operative technique must vary accordingly. As in every surgical procedure, the simplest technique associated with the minimum of trauma and shock to the patient should be chosen, as well as the one which will interfere the least with a future arthroplasty, should it be desired and prove feasible. From the technical standpoint, cases suitable for extra-articular arthrodesis of the hip can be divided into two groups, on the basis of pathologic and x-ray findings.

**Group 1.** In the first group, the destruction is moderate in amount without telescoping and the great trochanter remains widely separated from the side of the pelvis, so that a bone graft cannot be obtained from the side of the ilium or the immediate locality in sufficient length and strength to serve as a bridge for the extra-articular arthrodesis. The surgeon is compelled to go to the tibia or the outer portion of the upper end of the femur for graft material.

The patient is anesthetized to muscular relaxation and placed upon the fracture-orthopedic table. The surgeon forcibly cor-

in the particular case. This method of correction, partly by mechanics of the table, and partly by manual pressure over the



FIG. 2A. X-ray after many years of conservative treatment, showing marked bone destruction.

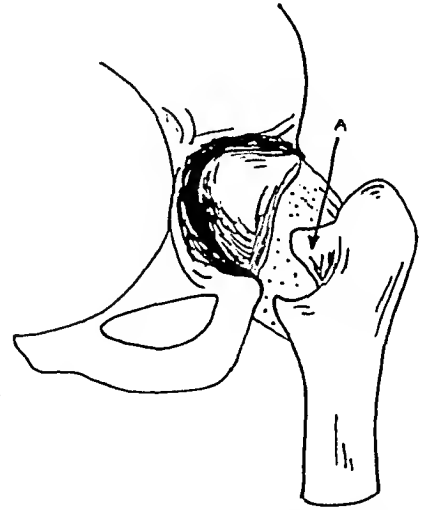


FIG. 2B. Schema of Figure 2A. Arrow A indicates a small spike of bone, all that remains of both head and neck of femur.

lower end of the femur, is adopted in order to guard against overstretching the lateral ligaments of the knee joint.

A somewhat curved incision starting at the crest of the ilium, 2 inches posterior to the anteroposterior spine and carried down below the great trochanter, is made through the skin. The gluteal muscles are separated sufficiently to expose the side of the ilium at the points of mortise for the insertion of the proposed tibial grafts.

Because of the thinness and elasticity of the bone comprising the outer table of the ilium, a mortise suitable to receive the grafts can be satisfactorily made with an half-inch chisel driven through the outer table of the ilium obliquely upward between it and the inner iliac table, with the handle of the chisel in close proximity to the trochanter. With the cutting end of the chisel still in the mortise prepared by it, located 1 inch posterior to the antero-superior spine, and 1 inch below the crest of the ilium, the handle is depressed onto the outer surface of the trochanter at its anterior border, and used as a guide for some cutting tool, such as the scalpel, to mark on the periosteal structures the line

rects the adduction of the diseased hip by manual counter-pressure, placing one hand against the buttock and the other against the inner aspect of the knee. His assistant at the same time, by adjusting the fracture-orthopedic table, places the well leg in the limits of physiologic abduction and cautiously swings into a position of abduction—the traction arm of the table holding the diseased leg. The amount of abduction in which the latter is placed depends upon the amount of bony shortening. The practical shortening of the operated leg should never be less than  $\frac{1}{2}$  inch. Locomotion is better when there is a little apparent shortening in the limb of the ankylosed hip. When the shortening is so great that it cannot be made up in a practical way by fusion of the hip at an obtuse angle with the pelvis, the surgeon must use his judgment as to the degree of abduction desired

## Albee—Hip Joint Fusion

where the motor saw is later to prepare a trochanteric gutter for graft No. 1. The same preparation is made for graft

set with the blades approximately  $\frac{5}{8}$  inch apart, a graft is removed by saw cuts made downward from the tubercle of the tibia

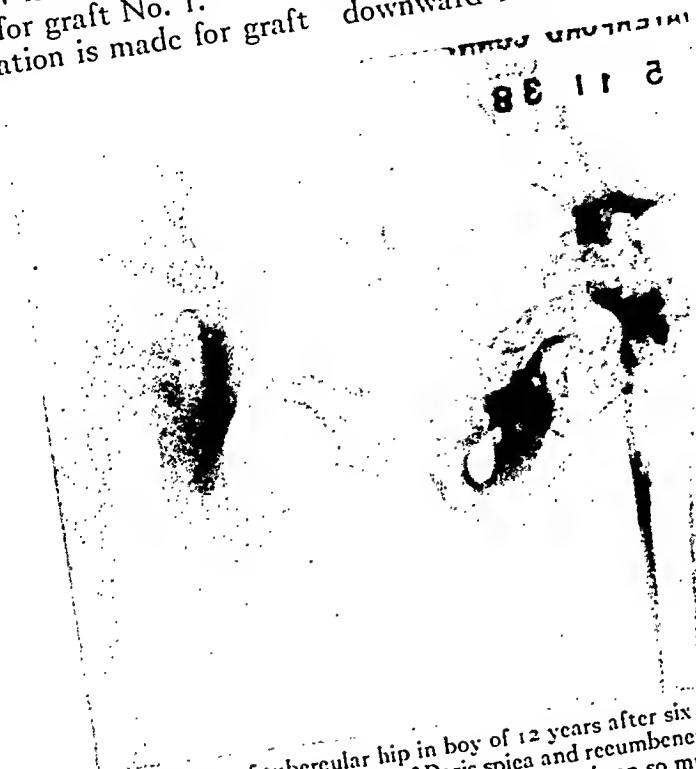


FIG. 3. X-ray of tubercular hip in boy of 12 years after six years of immobilization in a plaster of Paris spica and recumbency in bed. In spite of this constant treatment, there has been so much bone destruction that the pelvis on the involved side has been bisected and marked disintegration of the femoral head and neck and of the acetabulum has taken place.

No. 2, except that the mortise in the ilium is made about  $1\frac{1}{2}$  to 2 inches posteriorly to the first one, and the scalpel mark is made on the posterior outer surface of the great trochanter. These cuts beside chisel No. 1 and 2 are in the relation of rafters to a ridge pole.

Saw cuts are now made  $\frac{1}{2}$  inch in depth with the motor saw, following the scalpel marks just made on the trochanter. With an osteotome driven into these saw cuts, fragments of the trochanter are displaced with the periosteal soft parts as hinges, anteriorly from the saw cut for graft No. 1 and posteriorly from the saw cut for graft No. 2, so as to produce gutters to receive the two grafts with pedicled bone fragments to pull over them.

The antero-internal surface of the tibia is then laid bare from the tubercle of the tibia downward. With the motor twin-saw

about nine inches. With a motor saw, this strip of bone is then cut into two segments. The upper ends of the grafts are cut in an oblique way like the end of a chisel.

The upper end of graft No. 1 is inserted into the mortise of the ilium with its lower end lying in the anterior gutter prepared in the trochanter. The oblique surface at the upper end is outward. With the author's bone drift or set (of which the carpenter's nail set is the prototype) placed on the trochanteric end of the graft, the graft is now driven into the iliac mortise. In this manner, its trochanteric end is made to slide along the trochanter gutter and its proximal end to penetrate the mortise of the ilium by means of blows of the mallet upon the bone set.

Graft No. 2 is put in by precisely the same technique. The firmer the grafts are driven into the iliac mortise, the closer do

they hug the bottom of the trochanteric gutter because of the obliquity of the cut end of the iliac end of the graft. This plan

work should not supplement the extra-articular grafts in fusion operations.

The soft parts with fragments of the



FIG. 4A. Same case as in Figure 2. Fusion resulting from iliac bone graft. Note large cavity has been filled with new bone, induced by active bone-forming properties of the bone graft.

of operation automatically immobilizes the grafts at both ends in a most gratifying way and no immobilizing bone ligatures are necessary, with the exception of those placed to pull the soft parts with incorporated bone fragments over the lower end of the grafts at the trochanteric gutters. It is undesirable to enter the joint which is usually filled with extensive ichor or tuberculous pus, and likely to increase in amount, because of the operative trauma and the unfortunate likelihood of its flowing about the bone grafts.

The bone graft must always be placed in an environment of healthy vascular tissue, when possible, and fluid of any kind about it, particularly pus, should always be avoided. If the soft tissues surrounding a graft become infected, it is very likely to lead to the death of the graft. This is one of the principal reasons why intra-articular

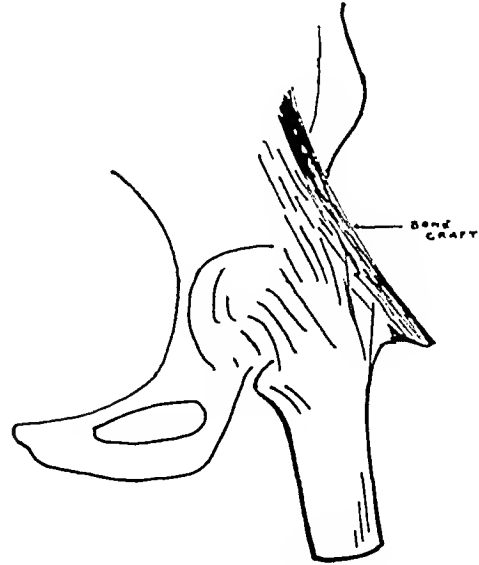


FIG. 4B. Schema of Figure 4A.

trochanter are drawn over the ends of the graft by means of interrupted strands of medium kangaroo tendon. The gluteal muscles are carefully drawn about the grafts by means of No. 2 chromic catgut sutures.

The skin is closed with continuous suture of o plain catgut. Suture holes and the edges of the wound are puddled with 3½ per cent tincture of iodine.

In three cases a strong graft about 5 inches long and comprising about one-fifth the diameter of the shaft of the femur from the tip of the great trochanter downward was obtained with a pedicle of muscle at its upper end. The lower end of the femoral graft was swung anteriorly on the muscle and soft tissue pedicle at the upper end as an axis until its anterior end came in contact with the side of the ilium. When the desired location on the ilium was thus determined, a flap or trap-door of the outer table of the ilium was turned slightly upward and backward by means of the motor saw and ½ inch osteotome, so that the upper end of the graft (formerly the lower end) could be thrust backward beneath it. Bone fixation ligatures were not necessary as when the graft is tapped with

a few blows of the mallet and bone drift firmly into place, it will not displace.

The Haas or Hibbs procedure is some-

resection of muscles, and possible shock. The procedure is the most difficult of the three types of techniques presented. The



FIG. 5. Same case as in Figure 1. After extra-articular arthrodesis by two tibial grafts. Note the remarkable bone repair. Density has come back to both pelvis and top of femur. Spaces formerly filled with caseous material are shown to be completely obliterated with the ingrowth of healthy bone. This patient was so completely relieved of all symptoms and had gained so much in weight, that her mother brought her back from Mexico, one year after operation, to request an arthroplasty operation to restore motion to the hip. However, I did not deem this advisable at such an early date.

what similar to this method except that Hibbs' method is not truly extra-articular, as both his diagrams and the description of his technique show that the neck of the femur is exposed and the cortex removed. The operation is therefore necessarily within the tuberculous area, which is to be avoided. Furthermore, this technique requires an extensive operative field, wide

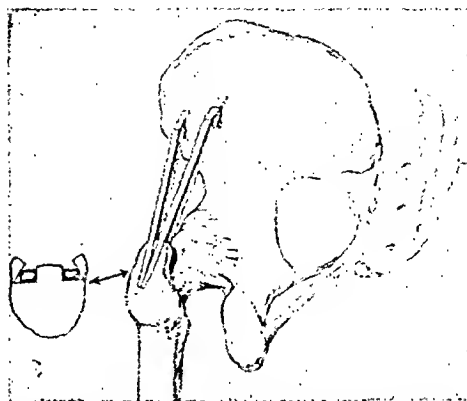


FIG. 6. Diagram showing method of implantation of tibial grafts into great trochanter and side of ilium.

author has so modified this operation that it is extra-articular, but the great trochanter and attached muscles are much more damaged than when the tibial grafts are used. It leaves more unfavorable conditions for a future arthroplasty to restore motion—a possibility which should always be borne in mind in planning such operations. Again this technique furnishes only one graft of weak, thin cortical bone which may fracture. In fact, in one of my three cases, the graft did break (Fig. 6) but united firmly after re-application of a double plaster of Paris spica for 8 weeks.

*Postoperative Dressing.* Postoperative dressings including splintage are very important. Extensive dressings of gauze and sterile cotton are applied, and then a plaster of Paris double spica from just below the umbilicus to the base of the toes on the operated leg, and to the tubercle of the tibia of the opposite leg, in a posture of abduction sufficient to overcome within  $\frac{1}{2}$  inch practical shortening, if feasible.

With the plaster still in a semi-plastic state, it is carefully moulded over the operated area, for two purposes: to favor immobilization and to aid in the control of bleeding.

The plaster is removed ten weeks from the time of operation.

*Group 2.* This group comprises those cases in which the destruction has been so extensive that the trochanter has approximated the rim of the acetabulum to a sufficient degree, so that a sliding graft from the outer table of the ilium including the outer half of its crest, is adequate to reach from the side of the ilium into the trochanter, which is split with  $1\frac{1}{2}$  inch osteotome from the superior surface of the neck of the femur outward to receive it. This technique furnishes adequate contact with these bony elements and still allows the surgeon to keep outside of the tuberculous joint. The side of the ilium has already been laid bare by the Smith-Petersen approach and furnishes with the outer half of its crest a very satisfactory graft in that this outer table not only is curved so that it approximates the trochanter and ilium satisfactorily, but also enables the surgeon to secure a very broad graft. This technique necessitates but one incision and is somewhat less difficult of execution and consumes less time than obtaining a graft from the tibia or femur, as described under Group 1. The surgeon, after sizing up the mechanical conditions, may therefore choose this type of technique rather than the other two already described.

*Indications for Operation.* Extra-articular arthrodesis is indicated at all ages. (1) Whenever there is constant relapse of the abduction deformity in spite of conservative measures to overcome it, such as traction in bed, braces, etc., after long periods of such treatment. (2) If the abduction deformity recurs following Gant's osteotomy, because of the hip not being completely ankylosed. (3) If the x-ray reveals destruction of the head or acetabulum or both, even if it is moderate. (4) If there are symptoms of active tuberculosis. The advantages of extra-articular arthrodesis for advanced tuberculosis of the hip with destruction is well illustrated by two contrast cases.

*Relative Difficulties of Technique.* Where the great trochanter is in close proximity to

the rim of the acetabulum, the simplest bone graft operation possible for extra-articular arthrodesis is applicable; the



FIG. 7. X-ray showing bone graft at *a*, consisting of great trochanter and upper portion of the femur.

sliding down of a broad graft from the outer table of the ilium, including the outer half of the crest into the split trochanter.

The tibial grafts are next in order of difficulty. The most difficult operation, particularly as to extent of operative field and tissues involved is the Haas or Hibbs technique. A graft of 4 or 5 inches taken from the outer portion of the great trochanter and the shaft of the femur can be used to accomplish an extra-articular arthrodesis. This, however, is an operation of considerable magnitude in that an incision has to be made from just below the crest of the ilium to nearly one-third down the thigh in order to rotate the graft into position.

*Caution.* A word of caution concerning the execution of these operations is stimulated by recent observation of a lantern slide reproduction of postoperative results elsewhere, in which it was claimed that extra-articular arthrodesis of the hip had been attempted, but with unsatisfactory results in a considerable percentage of cases. The x-rays showed that the same inadequate and imperfect technique had been practiced as has been so frequently observed during the past twenty-eight years, when certain men have drawn unfavorable conclusions from their at-

tempts to accomplish extra-articular arthrodesis of tubercular spines, although the operative technique was so poor that a good result could not possibly follow. The most frequent cause of failure has been found to be either too short grafts with inadequate mortising into the elements on each side of the joint, or grafts of too small diameters or too weak to resist breakage.

The author wishes again to emphasize the necessity of the graft being of sufficient strength, ample length, with accurate fit and careful extensive mortise into the bony element on either side of the joint. Two illustrative cases with x-rays are cited, contrasting the end results of cases with marked destructive tendencies after conservative and operative treatment.



IN the maintenance of good digestion, roughage cannot take the place of rest, exercise, good diet, and a generally well-ordered life. . . . Bran is pleasant preventer of constipation, but a sad cure.



# TREATMENT OF ACUTE STAPHYLOCOCCIC SUPPURATIVE ARTHRITIS

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THE treatment of acute staphylococcic suppurative arthritis presents one of the most difficult problems in the entire field of medicine. The mortality is high and the end results in the surviving patients are very poor. Nathan<sup>1</sup> stated in 1932, "In contradistinction to the conditions which are inherent in streptococcus and pneumococcus infections, there is in staphylococcus coxitis always massive necrosis, which invariably leads to sequestration and chronic suppuration. The acute symptoms may, if the patient survives the sepsis, subside, but recurrences at longer or shorter intervals are bound to occur so long as the diseased bone remains in situ. I am still convinced that these patients are never cured until the joint is completely obliterated and an end-to-end synostosis between the articulating bones has taken place." The pessimistic views expressed by Nathan are in accord with those of most of the profession.

A survey of the literature reveals that only recently has it been recognized that there is a difference in the clinical course, pathology and requirements of treatment of staphylococcic suppurative arthritis as contrasted with streptococcic or pneumococcic suppurative arthritis. It has never been suggested that there are widely varying forms of staphylococcic suppurative arthritis which are entirely different in their clinical course, pathology and requirements of treatment. With the hope that a better understanding of the clinical course and pathology of acute staphylococcic suppurative arthritis would lead to more effective methods of treatment and more satisfactory end results, an

attempt was made to simulate the disease experimentally.\*

The knee joints of a series of rabbits were inoculated with 500 million staphylococcus aureus (0.5 c.c. of a saline suspension from an eighteen hour agar slant culture) isolated from cases of acute suppurative arthritis and osteomyelitis. These animals developed typical suppurative joint lesions with marked swelling, local heat and redness of the knee joint region, and flexion contracture of the knee and hip.

In the animal experiments, the factor of host resistance could be regarded as constant, greatly simplifying the interpretation of results. In these preliminary studies, it was found that the lesions produced in the animals tended to be of two distinct types:

1. The animals inoculated with the ordinary abscess producing type of staphylococcus aureus tended to develop markedly invasive local lesions with multiple metastatic abscesses.

2. The animals inoculated with the toxicogenic type of staphylococcus aureus tended to develop mild, non-invasive local lesions with marked toxic degeneration of the viscera. The visceral lesions were similar to those which Rigdon<sup>2</sup> and de Navasquez<sup>3</sup> produced by the intravenous injection of staphylococcus toxin.

The analysis of the results of these animal studies revealed that there are definite requirements which must be met if treatment is favorably to influence the course of the disease.

\* In collaboration with Marjory B. Patterson, B.Sc., and through the courtesy of Ward J. MacNeal, M.D., Director of Pathology and Bacteriology, New York Post-Graduate Medical School and Hospital, Columbia University.

**Requirements of Treatment.** Acute staphylococcic suppurative arthritis is a systemic disease. Although the local treat-

flushed with warm normal saline as often as it becomes distended, in some cases, every eight hours. The laboratory immediately

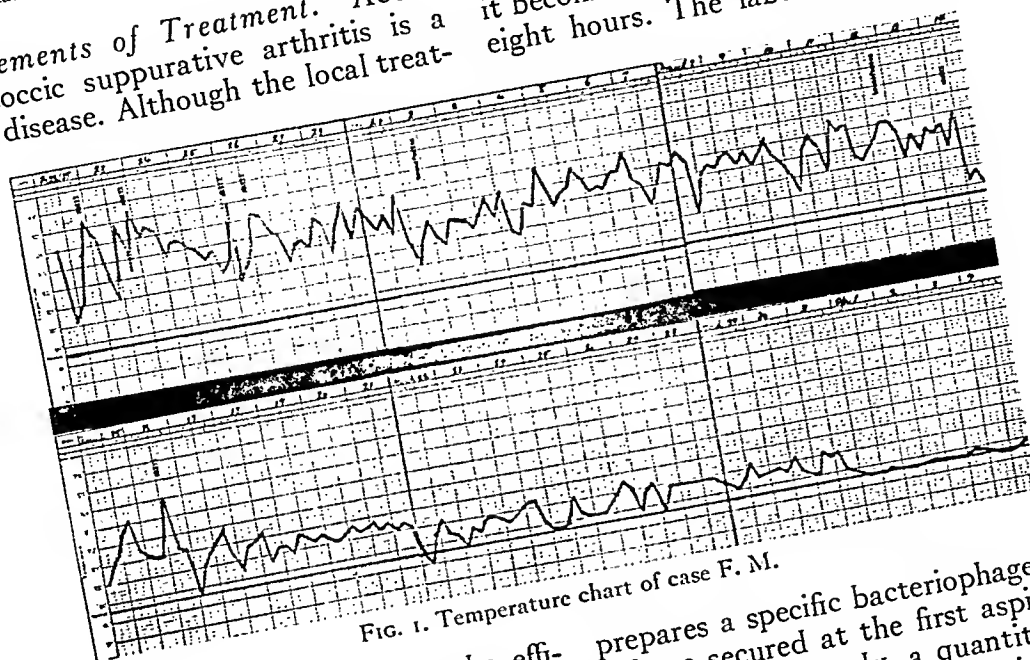


FIG. 1. Temperature chart of case F. M.

ment of the infected joints must be efficient, if future disability is to be avoided, the treatment of the systemic toxemia or septicemia is of greater importance.

Each case must be treated as if both the toxicogenic and abscess producing varieties of the organisms were present because there is no clinical or common laboratory method for differentiating them quickly.

The course of treatment outlined below is compatible with the theoretical requirements established by the experimental studies and has proved to be effective in practice:

1. *Aspiration of the Joint.* The organism infecting the joint must be identified as soon as possible so that the proper treatment can be instituted before permanent damage is done.

2. *Destruction of the Organisms Locally.* The products of bacterial growth are destructive to the synovia and articular cartilages. The irritation of the synovial membrane in the early stages of the inflammation causes an increase in the amount of synovial fluid secreted. This fluid, together with the bacteria and the products of bacterial growth distends the synovia enough to cause further injury and constant pain. The joint is aspirated and

prepares a specific bacteriophage from the culture secured at the first aspiration. As soon as this is ready, a quantity equal to one-half the amount of the aspirated pus is instilled into the joint before the aspirating needle is withdrawn. Ninety per cent of the strains of staphylococcus aureus are lysed by their specific bacteriophages. Albee<sup>1</sup> has demonstrated the effectiveness of local bacteriophage therapy in bone and joint infections. The bacteriophage seems to destroy the organism without injury to the synovia or articular surfaces. In this it differs from all chemical substances used to kill bacteria by local application.

3. *Rest of the Inflamed Joint.* It has long been recognized that traumatized joints heal more quickly if they are immobilized. The general condition of the patient improves more rapidly if the pain resulting from the constant motion of the inflamed joint can be stopped without the use of narcotics. In all cases, the suppurative joint is immobilized with a split plaster of Paris cast or traction. This should be done immediately before the joint dislocates, a complication frequently seen in the hip and knee. The immobilization should be continued until the inflammation has completely subsided. As long as joint motion is

painful, there will be a tendency for the patient to hold the extremity in the comfortable position of deformity. Contrac-

autogenous bacteriophage intravenously according to the method of MacNeal.<sup>6</sup>

#### 5. Destruction of the Toxin Elaborated by



FIG. 2. Range of active painless motion of right elbow four years after the infection.

tures soon develop which unnecessarily prolong the period of disability.

4. *Prophylaxis against Multiple Metastatic Abscesses.* In most cases of acute staphylococcic suppurative arthritis the involved joint is infected by way of the blood stream. Multiple metastatic abscesses in the viscera, bones and joints are frequently seen. In some cases in which these metastatic, blood-borne foci appear, repeated blood cultures are negative. MacNeal states: "In the animals receiving the injections of bacteriophage, there was a relative protection of the various organs from localization of the infectious agent."<sup>5</sup> He suggests that the bacteriophage aids the body defenses against the bacterial invader by favoring more effective phagocytosis. All patients with acute staphylococcic suppurative arthritis should be given

*the Infecting Organism.* Both varieties of staphylococcus aureus produce toxin which is absorbed into the blood stream. The anemia which always develops in patients infected with either the toxicogenic or the ordinary abscess producing type of staphylococcus aureus is proof that even the latter variety, which is not classed as an exotoxin producing organism, elaborates enough hemolytic toxin rapidly to destroy the red blood cells. In the experimental studies, it was found that the animals inoculated with the toxicogenic type of staphylococcus aureus developed toxic hepatitis, toxic degeneration of the myocardium, diffuse cloudy swelling of the kidneys with degeneration and necrosis of the epithelium of the glomeruli. Theoretically, specific antitoxin should be given these patients. In the animal studies, the commercial

specific antitoxin which was injected did not protect the viscera of the infected animals against the degenerating effects of

staphylococcus toxin. For this reason large doses of vitamin c are given to the patients.

#### 6. Increase the General Resistance of the



FIG. 3. Range of active painless motion of left knee four years after infection.

the toxin. Lethal doses of toxin could be injected intravenously into non-infected animals along with the proper amount of antitoxin without harmful effect on the animal. In the infected animal, the organism seems continuously to produce such large amounts of toxin that the amount of antitoxin which can be given is inadequate to protect the viscera.

The best available treatment is frequent small blood transfusions. They are most effective if the donor has been immunized against the strain of staphylococcus aureus infecting the patient. In this way the antitoxin titer of the transfused serum can be raised.

Mercier<sup>7</sup> has demonstrated that cevitic acid inhibits the hemolytic power of

*Patient.* It is recognized that acute suppurative arthritis is a systemic disease in which the joint inflammation is only an incident. Therefore, the basic principle of treatment of all systemic disease must be observed—build up the patient. Of the measures used, the most important are a high vitamin diet and ample fluids by mouth.

Many of the patients have subclinical scurvy, particularly those who have had a prolonged illness. In the presence of this condition, bone and fibrous tissue repair is slow or absent.<sup>8</sup> The vitamin deficiency need not be marked enough for detection by clinical tests for this delay in healing to take place.<sup>9</sup> For this reason, all patients should receive a high vitamin diet.

7. *Restoration of Motion.* When the temperature has been normal for ten days and there are no signs of localized inflammation around the involved joint, the immobilization should be removed. If two or three days of unrestricted motion do not cause a flare-up of the inflammation, massage and cautious passive manipulation of the joint can be started. If a weight-bearing joint is involved, the patient should now start to walk with crutches. If there are signs of an exacerbation of the joint inflammation at any stage in the treatment, the immobilization should immediately be reapplied. Massage and active and passive manipulation bring about a recalcification of the weakened, osteoporotic, bone adjacent to the articular surfaces, as well as stretch the adhesions limiting motion.<sup>10</sup> If, after three weeks of treatment, the range of motion has not increased, and the x-ray shows no bony abnormality which would prevent motion, the joint should be manipulated under anesthesia. Following the manipulation, the massage and active and passive motion must be continued each day to maintain the range of motion secured at operation. The screw-control brace<sup>10</sup> is of great value after manipulation of the knee or elbow.

#### CASE REPORT

The following case is reported to illustrate the principles of treatment:

F. M., male, age 18, had a sudden onset of fever (104 degrees) on February 8, 1935. At that time, there was no complaint except lethargy, and examination failed to reveal any signs of localized inflammation. The elevation of temperature continued. Ten days later, the patient had a chill and began to have swelling and pain in the right elbow and left knee. Four days later, he was admitted to a hospital. Figure 1 shows the range of temperature during the first week in the hospital; it rose to 105 degrees on four days with four chills. On the fifth day in the hospital, a soft tissue abscess on the left foot, which had been present for two days, was incised.

When the patient was first seen by the author, at the beginning of the second week in

the hospital, the right elbow and left knee were immediately aspirated. Before the removal of the needle, the joints were flushed with warm normal saline until the return flow was clear. The elbow was immobilized with a Velpeau bandage and traction applied to the leg. The elbow required no further treatment and the immobilization was removed in five days.

The culture of the thick pus from the knee and elbow showed hemolytic staphylococcus aureus. The laboratory immediately started to prepare an autogenous bacteriophage in broth medium for local use and in asparigen, non-protein medium, for intravenous injection.

The knee was aspirated and washed with saline as often as it became badly distended, every twelve hours at first. After three days, the laboratory was able to furnish autogenous bacteriophage in broth medium. A quantity equal to one-half the amount of fluid withdrawn from the knee was injected at each aspiration (20 to 40 c.c.).

The temperature curve remained at a lower level during the second week of hospitalization, below 104 degrees. During this week, two 400 c.c. direct blood transfusions were given. During the period of hospitalization, four blood cultures were taken, all of which were negative. After seven days, autogenous bacteriophage in asparigen medium was ready for use and the intravenous injections were started. It was given in divided doses every forty minutes, starting with 0.5 c.c. and working up to 10 c.c. This dose was repeated until a total of 200 c.c. had been given. A single dose of 10 c.c. was given on each day following. It will be noticed that there was no change in the level or character of the fever curve for seven days. On this day, the patient had a severe chill following the intravenous injection of the bacteriophage. No phage was given on the next day; the inflammation of the knee had subsided considerably, aspiration being necessary only every twenty-four to thirty-six hours. On the next day, the intravenous phage was started again with a half dose (5 c.c.). Immediately there was a severe chill. It will be noticed that following this, the temperature stayed below 101 degrees and gradually dropped to normal. It was not necessary to aspirate the knee again and recovery was uneventful. During the entire period of hospitalization, the patient was given a high vitamin diet and fluids were forced by mouth.

## Preston—Suppurative Arthritis

Figures 2 and 3 show the range of active motion of the right elbow and left knee four years after discharge from the hospital.

Six weeks of daily manual massage and a manipulation of the knee, under general anaesthesia, were necessary to secure this functional result.

## SUMMARY

1. The plan of treatment of a case of acute suppurative arthritis must be based upon certain fundamental requirements.
2. These requirements are listed and discussed.
3. A case is reported which illustrates the application of these principles.

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# ORTHOPEDIC CONSIDERATIONS IN THE TREATMENT OF ARTHRITIS\*

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THE care of the joints in arthritis cannot be over-emphasized. In atrophic arthritis, particularly, it is common for the clinician to become so submerged in measures directed toward possible etiologic factors and general therapeutic procedures that attention is not given to the care of the joints until they become hopelessly deformed.

Measures directed toward the joints form a basic part of the therapy in all types of arthritis. The procedures indicated depend upon the type of disease and the phase of the condition. They must be based upon a conception of the pathologic process presented by the individual's joints and an appreciation of the effect of available measures upon the process. They should have a specific purpose. If, for example, it is felt that physiotherapy is indicated, the clinician should give definite direction to the procedures that are to be performed, carefully considering the status of the joints, what it is desired to accomplish, and the possibilities and limitations of the particular techniques.

Since the term arthritis includes diseases which show vastly different pathologic processes, it is necessary to consider the therapy under the various types of arthritis. Particular attention will be given to the two major types of chronic disease: "atrophic arthritis" and "hypertrophic arthritis." This classification is used since these terms have been approved by the American Committee for the Control of Rheumatism. It is understood that rheumatoid arthritis, proliferative arthritis, and infectious arthritis are terms synonymous with atrophic arthritis. All of these have justification for their use except

"infectious arthritis," since infection has never been proved to be the etiologic factor. Osteoarthritis and degenerative arthritis are other terms given to hypertrophic arthritis.

Septic or pyogenic arthritis will not be discussed since it is the subject of another paper in this issue of the Journal. This condition must be particularly suspected in any acute monarticular arthritis with fever.

It is appreciated that arthritis is a general problem, and it is understood in the discussion of local measures that all other procedures which may influence the disease are performed.

## ATROPHIC ARTHRITIS

The clinical picture of fulminating atrophic arthritis is a familiar one: generalized symmetrical involvement, painful swollen joints, progressive deformities, and if severe and uncontrolled, invalidism. It may arise at any age, although more commonly at ages under 40. It may appear as early as the second year of life.

In its worst form, the disease is rapidly progressive. The individual has more or less fever, loses weight even to emaciation, and shows hyperplasia of lymphoid tissue. The latter is particularly true in the disease as seen in children, so-called Still's disease, in which the spleen may be greatly enlarged.

The joints are frequently so sensitive that the patient tends to remain almost constantly in a position of deformity, which in the individual joints is that position characteristic of any intra-articular irritation. (Fig. 1.) There is marked spasm of the deforming muscles with extreme

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## Green—Arthritis

atrophy of the antagonistic muscles. The hips tend to become flexed and adducted, the knees flexed, and the feet to go into

may hyperextend and become subluxated. (Fig. 2.) Subluxation is common in the hand as it is elsewhere.

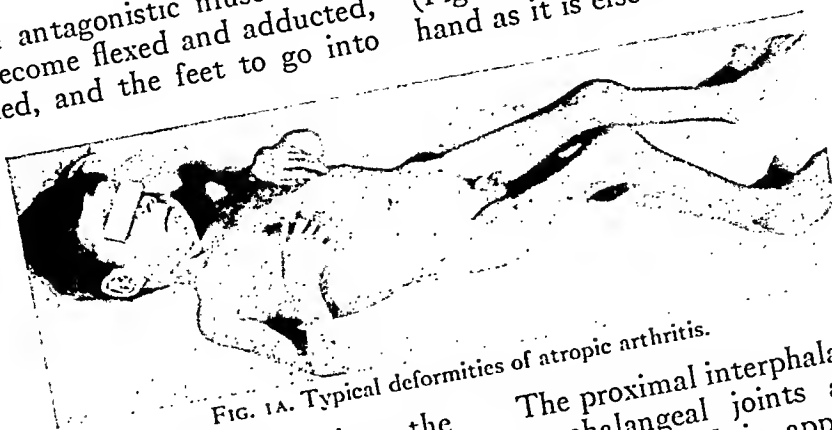


FIG. 1A. Typical deformities of atrophic arthritis.

equinus. In the upper extremity, the shoulders become adducted, the elbows flexed, the forearms pronated, and the

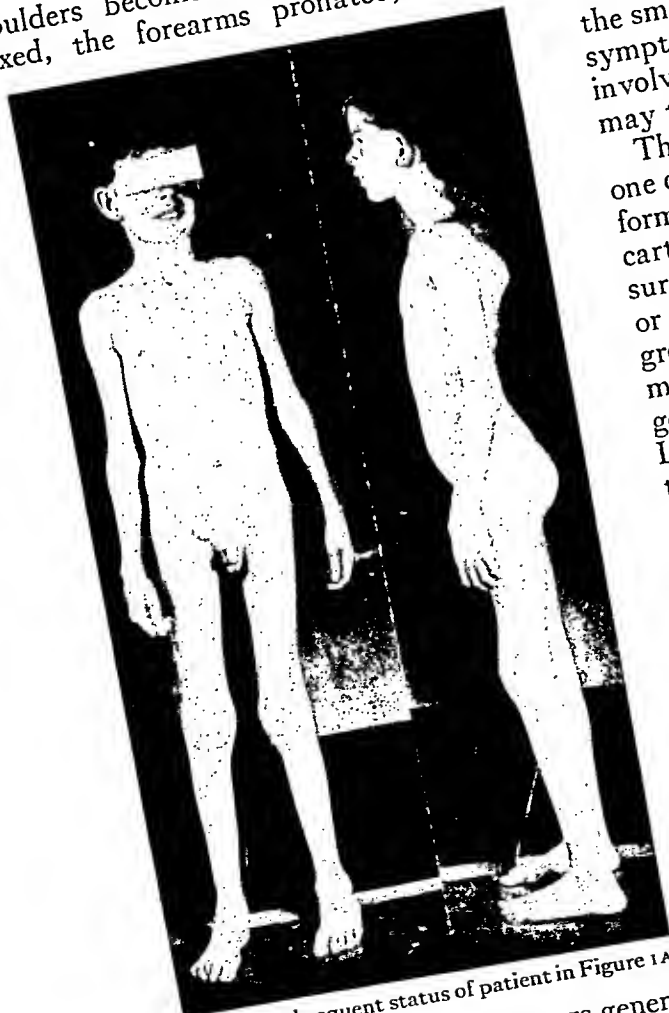


FIG. 1B. Subsequent status of patient in Figure 1A.

wrists go into flexion. The fingers generally show flexion and ulnar deviation except the proximal interphalangeal joints which

The proximal interphalangeal and metacarpophalangeal joints are so typically affected that their appearance may be diagnostic of the disease. It is common for the small joints to be the site of presenting symptoms. The cervical spine is usually involved and shows a flexion deformity, as may the rest of the spine.

The pathologic process in the joints is one of inflammation of the synovia, pannus formation which encroaches upon the cartilage with destruction of the joint surface, and a tendency to either fibrous or bony ankylosis. The bone becomes greatly atrophied; this is the only abnormality that can be recognized in roentgenograms in the early stages of the disease. Later, narrowing of the joint and destruction may be seen.

The active stage of the disease may last for years, but as a rule it gradually becomes quiescent. If deformities have been prevented and joint motion has been preserved, the patient may have very satisfactory function. If deformities have been allowed to develop, subluxation and ankylosis to occur, the individual may be completely helpless, despite the fact that the joints are no longer sensitive.

The joints demand attention from the outset. The local measures indicated depend upon the activity of the process, the joints involved, and the phase of the disease, although they must necessarily be modified by the social and economic status of the individual.



The treatment of the joints is outlined by considering the local disease. The joints primarily show inflammation. Inflamma-

atrophy of those muscles which oppose deformity.

Considering the above factors, we may

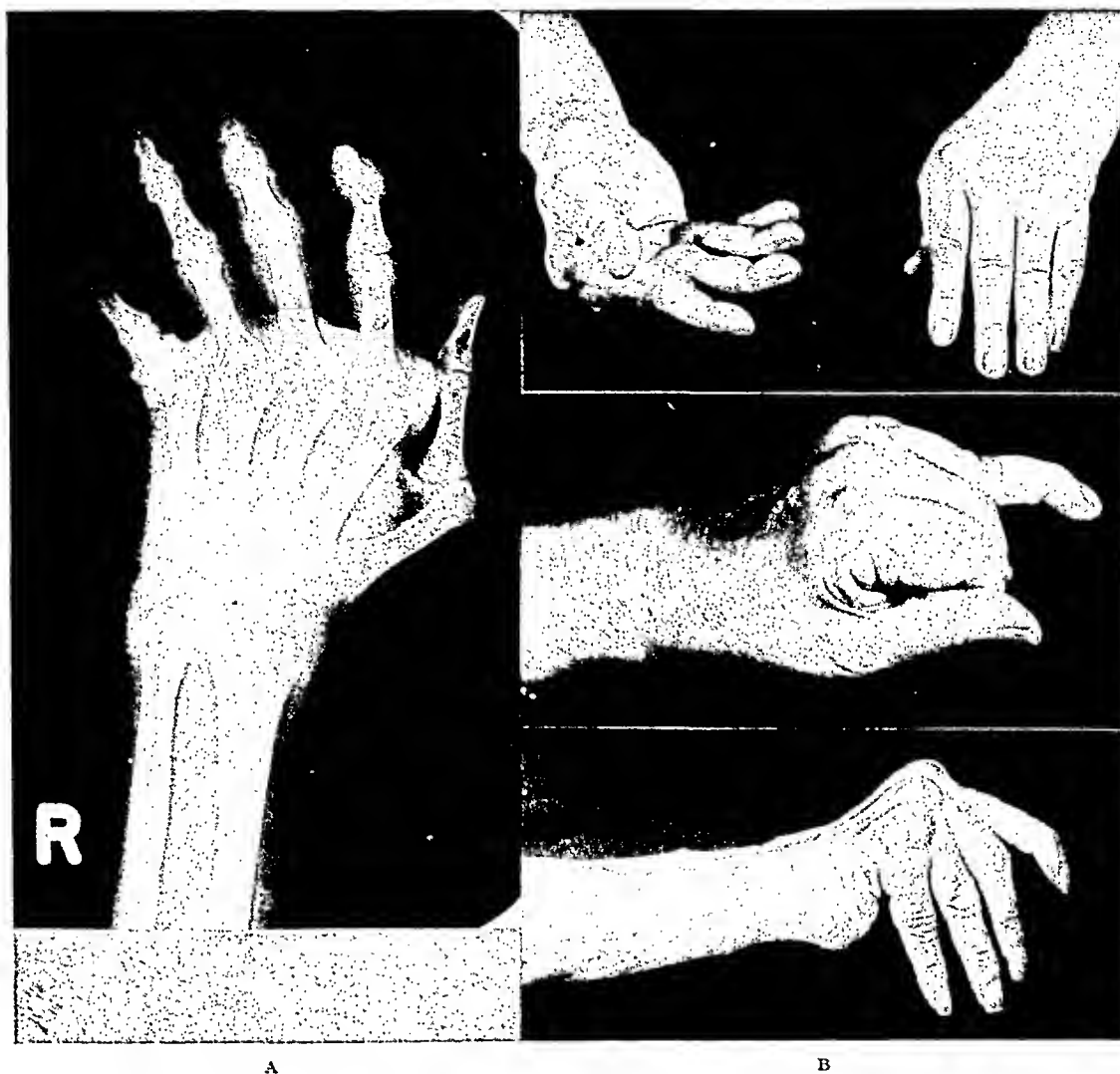


FIG. 2. Deformities of the hands in atrophic arthritis. A, note subluxation of metacarpophalangeal joints, atrophy of bone, and narrowing of joint spaces.

tion is ideally treated by rest, and atrophic arthritis is no exception. The joint, however, by its anatomic and physiologic structure modifies the usual dictum of absolute rest in inflammation. The cartilage demands motion. A normal joint, if immobilized for a long period, becomes stiff and the cartilage degenerates. The injury to the cartilage from prolonged fixation in atrophic arthritis is increased by muscle spasm which jams together the opposing surfaces of the joint in a fixed position. Secondary considerations are the marked atrophy of the bone which may secondarily affect the cartilage, and the

evolve the basic principles in the care of the joints: local rest, the prevention of deformities, the maintenance of motion, the minimizing of atrophy of those muscles opposing deformities, and measures to relieve pain. Rest, general and local, is probably the most important known therapeutic agent. It is likely that if we would treat the disease by rest in the early phases with the same radical attitude which exists in the treatment of tuberculosis, most of the tragedies from the disease could be averted. In the acute phases rest to the joint is best obtained by some form of immobilization which reduces muscle spasm

and prevents deformity, yet allows some motion each day as indicated. Movement of the joint is essential to prevent adhesions and ankylosis.

Ordinarily the position for immobilization in the acute phase closely approximates the optimal position for ankylosis. The desired attitude in ankylosed joints varies as to

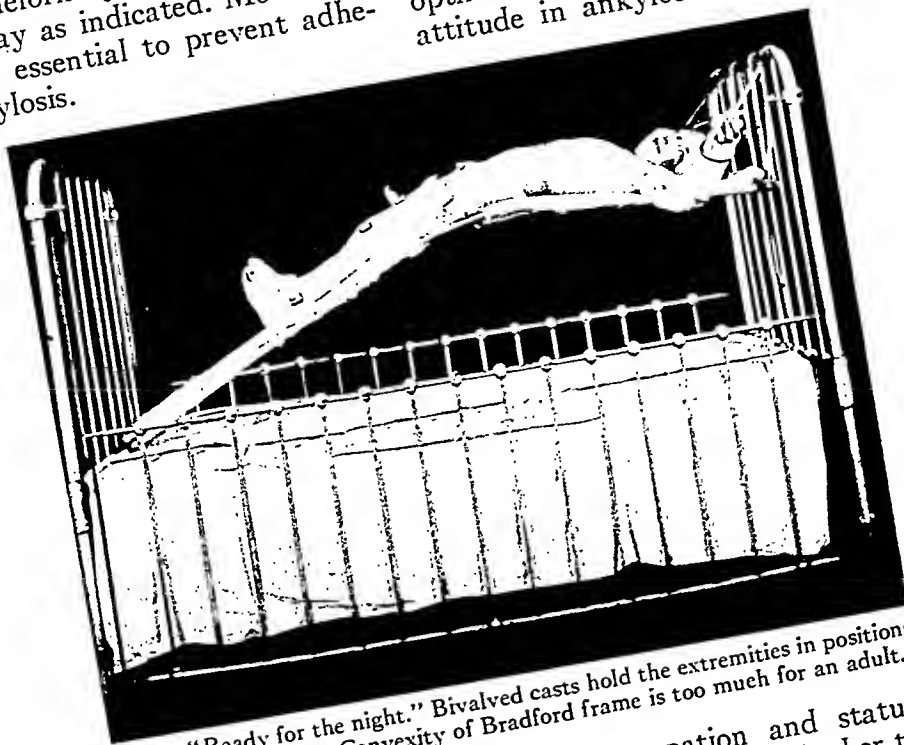


FIG. 3. "Ready for the night." Bivalved casts hold the extremities in positions opposing deformity. Convexity of Bradford frame is too much for an adult.

One method of preventing deformities and obtaining local rest is the use of splints or bivalved removable casts of plaster of Paris or other materials. The parts should be immobilized in a position opposite to that of the anticipated deformity, except for the elbow which is best placed at approximately a right angle. (Fig. 3.) The ideal position of immobilization of the upper extremity maintains the arm abducted at the shoulder and in external rotation, with the elbow held at a right angle and the forearm in supination. The wrist should be in dorsiflexion with the hand neutral as to radial and ulnar deviation, and the fingers slightly flexed, particularly the proximal interphalangeal joints. In the lower extremity, the hip should be extended, neutral as to rotation and in a little abduction, perhaps 15 degrees; the knees should be extended, but not hyperextended, with the foot at a right angle, and neutral as to pronation and supination.

If ankylosis is imminent, the joint must be in the optimal position for function.<sup>1</sup>

the occupation and status of the individual and as to whether the involvement is symmetrical. In the upper extremity they should ordinarily be in the position which allows the hand to approach the mouth without elevating the scapula, namely about 65 degrees abduction, 45 degrees flexion, and 35 degrees internal rotation. Ordinarily the shoulder does not become fixed in atrophic arthritis. If one elbow alone is stiff, the best position is usually at 100 degrees, that is, extended 10 degrees past a right angle. If both elbows are fixed, one should be just past a right angle, the other less than a right angle so that the mouth can be reached. The position of the wrist should be in dorsiflexion, neutral as to pronation and supination; the fingers should be in such position that apposition to the thumb may occur.

In the lower extremity, the position depends upon the future habits of the patient. If he is going to be in a sitting position for most of the time, the joints should be in more flexion. As a rule the hips

should be in 20 to 30 degrees flexion, 15 degrees abduction, and neutral as to rotation. The knees should be in a position of

Traction is started in the line of deformity, and combats muscle spasm, thus relieving the pressure of one joint surface

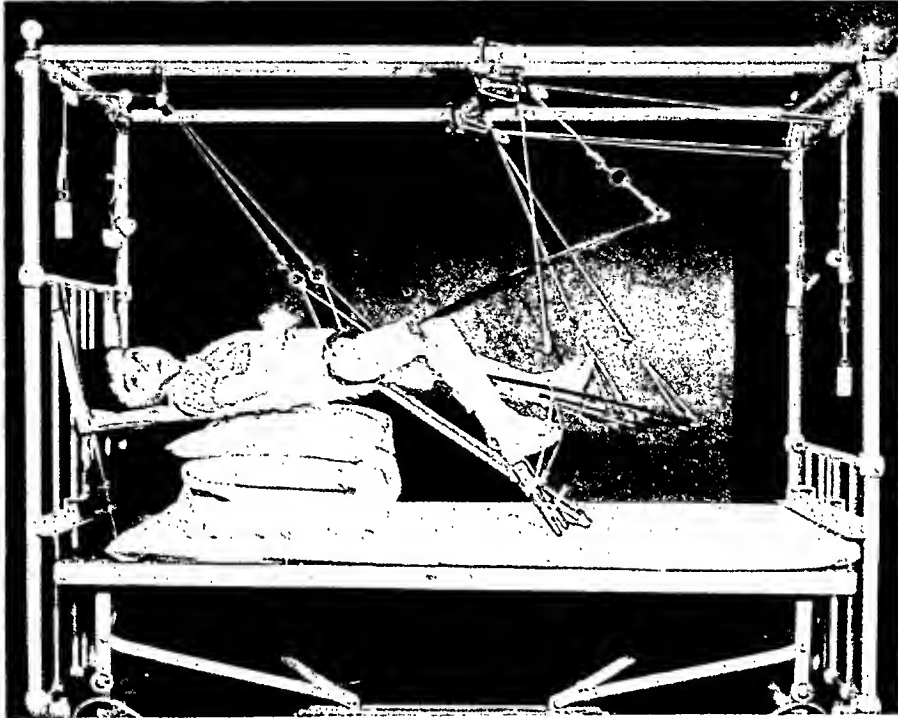


FIG. 4. Counterpoised traction for lower extremities. Patient has the two extremities in different positions, illustrating possibilities of motion.

10 to 20 degrees flexion, the foot in slight equinus, neutral as to inversion and eversion. A little pronation is preferable to supination. If more than one joint is stiff in the lower extremity, the position chosen for one depends upon the other.

Ordinarily, in arthritis, one need not be concerned about too little flexion with ankylosis, but rather the prevention of too much flexion.

If the patient seen during the acute phase already has deformity, it should be corrected gradually, not forcibly. With deformity or marked muscle spasm, we frequently use counterbalanced traction (Fig. 4) for immobilization and the instigation of motion.<sup>2</sup> Such traction is particularly helpful in the lower extremities, in which instance, a modified Thomas splint with Pierson attachment is used. The apparatus must be accurately balanced so that the patient may obtain motion with the least effort and the slings must be adjusted in order to prevent subluxation of the joints.

upon the other. Movement of an active type can therefore be started in the apparatus with less discomfort. Between periods of exercise, and particularly at night, the apparatus is locked to immobilize the joints in the best position obtainable. Those motions are stressed which are opposite to the deformity, and attention is given to the muscles which oppose the deformity. If the disease is very active, the individual may not be removed from the apparatus until this can be done painlessly. The degree of sensitivity controls the relative amount of immobilization and activity in the apparatus. At the start the parts are immobilized except for one or two periods during the day, when gentle active motion is performed, guided by the patient or a second person, avoiding discomfort so far as possible. If the joint is very sensitive, each motion is carried out only a very few times at the start. Later the apparatus may be left free for motion at any time except at night, and the individual may carry out increasing activity. The parts, when not

being exercised, should be kept in the corrected position the major part of the time, even when the apparatus is not locked in



FIG. 5. Controlled active exercises in Hubbard tub. Shape of tub allows free motion of extremities.

position. This can be easily managed by the patient due to the counterbalanced arrangement.

Attention must be given to the spine, including the cervical portion, if it is involved. A Bradford frame is frequently necessary, but if a bed is used, it must be unyielding, firm, and straight. Pillows under the head, which may cause a flexion deformity of the neck must be avoided.

Even if the process is such that immobilization of the types mentioned is not deemed necessary, constant effort must be made to prevent deformity by attention to the position of the parts, and by active exercises. When the disease is not particularly active, immobilization at night and during the rest periods is very helpful.

Physiotherapy. The measures during the acute phase are directed toward the maintenance of motion, combating atrophy in the muscles which are antagonistic to the

deformity, and relieving pain. Heat is helpful in allaying discomfort and as a preliminary measure to the exercises. Radiant heat may be used, although moist heat is frequently more soothing in very painful joints. The latter may be given either with wet towels heated with a lamp for radiant heat, or by placing the patient in a warm bath such as the Hubbard tub. (Fig. 5.) Prolonged heat is to be avoided.

If the Hubbard tub is used, exercises in water are given, always guided and active in type and directed toward decreasing the deformity. The temperature of the water is ordinarily from 98 to 100°F. It may be a little warmer, although never over 104°F., if the joints are very sensitive; or of lower temperature if the period in the water is to be quite prolonged. The buoying effect of the water is of great assistance, but too long a period in warm water is enervating and must be avoided. The movement of the joints must always be active or guided active, never passive. Passive motion increases spasm and pain, and does not allow as great a range of movement as do guided active maneuvers. The maximum arc of motion that may be obtained without undue discomfort should be secured each day. Ideally the range should be that which can be obtained painlessly, but a certain amount of discomfort is inevitable in most instances if function is to be preserved.

The exercises need not be done in water. If not, they should be carried out by a technician who supports and guides the part through its arc of active motion, assisting in the extremes as sensitivity permits. At first, if the joints are very sensitive, only three or four motions of each joint should be performed, but the exercises should involve all the possible directions of motion at the particular joint, always emphasizing motion opposite to deformity.

"Muscle setting" exercises are very useful in combating atrophy in muscles. (Fig. 6.) They can be done by the patient without assistance and are not painful. Since in "setting" the muscle is contracted with its origin and insertion closely

approximated, the stimulating effect of the exercise is greater than would otherwise be the case. These exercises are particularly

in amount to determine whether they are an irritating factor. There are certain days when the joints are more painful than



FIG. 6. Quadriceps setting. Phantom photograph with quadriceps relaxed and after "setting." Note shift of black dot over the patella and double contour of thigh.

helpful in the instances of the quadriceps and gluteus maximus.

Massage after the application of heat is a usual measure in conjunction with exercises and should be directed toward the atrophic muscles. Direct massage over sensitive joints is contraindicated.

If it is suspected that the exercises are too strenuous and are increasing sensitivity, they may be temporarily diminished

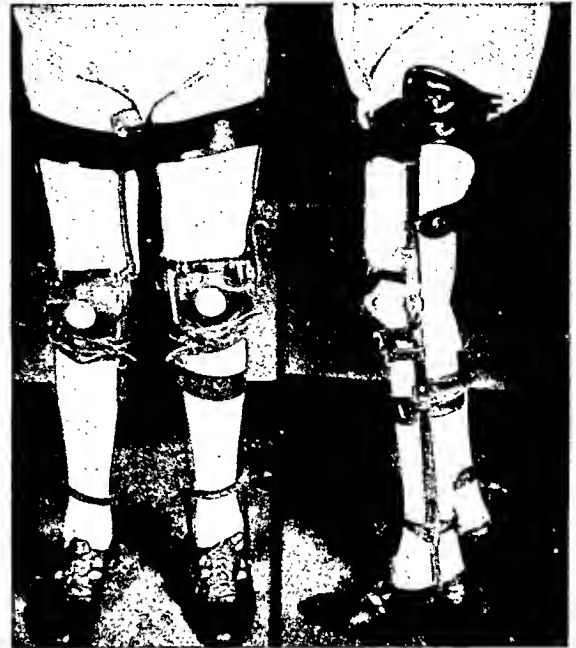


FIG. 7. Walking with caliper braces after flexion deformities of the knees have been corrected.

others, and activity on these days should be less. However, a certain amount of movement must be carried out, and rarely should a day pass without some motion. An accurate record should be kept of the arc of motion existing in the various joints and particular effort should be expended in maintaining it.

The correction of deformities and care during the very active phases are performed best in an institution. Once progress is being made and deformities are corrected, it is frequently possible to carry on at home. Some one in the household can usually be taught by the physiotherapist to guide the exercises twice a day. However, these must be checked at regular intervals by the clinician and the physiotherapist. The patient can carry out some of the exercises himself, but many require help and supervision. Ideally a trained physiotherapist should supervise the exercises at all times, but in practice, they must be done in such an amount that some one living with the patient should be able to assist with them. Immobilization is prac-

ticed at home as indicated as long as there is activity.

As the process becomes quiescent, exercises become more strenuous. Synovial thickening, sensitivity, and the general clinical picture, as well as laboratory determinations, are indices of activity. Walking must be attained gradually, and not before the muscles are strong enough to carry out their function. A therapeutic pool is of assistance when walking is started. Various supports may be necessary, such as caliper braces (Fig. 7) and crutches. Care should be given in the choice of shoes and frequently the feet must be protected by steel plates or flexible pads made in the form of an insole with the supporting factor either of felt or of sponge rubber. If deformity has not developed and motion has been preserved, the problem of rehabilitation may be relatively simple. Progress must be slow.

*The Correction of More Persistent Deformities.* If the patient has deformities which cannot be corrected by counterpoised traction and active measures with strengthening of the antagonistic muscles, various other procedures are available. Wedging casts may be used. If properly constructed, this type of cast may be bivalved so that periods of motion may be allowed each day. If the cast is of a type that cannot be removed for motion, it should be used for relatively brief periods, and rarely for over ten days unless the disease is quiescent.

Heavy traction may be desirable including skeletal traction. The traction must be in the line of the deformity, changing the direction as the deformity decreases. In flexion deformities of the knee with subluxation, an excellent method is to apply traction with two Kirschner wires, one through the upper end of the tibia to which traction is applied in the anterior direction, and the other through the distal end of the tibia or os calcis with traction in the longitudinal axis of the tibia.

Gentle manipulation under anesthesia is occasionally indicated, both to correct

deformity and to attempt to increase the range of motion. Ordinarily it should not be done except in the arrested stage, although occasionally it is desirable during periods of mild activity. Immobilization combined with guided active exercises are the important features after any corrective measures.

*Operative Procedures.* Various operations may be necessary to correct deformities. Plastic procedures involving the capsule of the joint and other contracted structures may be indicated. In the knee, posterior capsuloplasty, as described by Wilson,<sup>4</sup> may be helpful, and, if indicated, may be combined with skeletal traction as mentioned above. Division of the fascia lata and intermuscular septa may facilitate the correction of flexion-abduction deformities of the hip, as may division of the iliotibial band and adjacent septum<sup>5</sup> aid in correcting flexion contractures at the knee and knock-knee.

Osteotomy may be indicated either to shift the available range of motion to an improved functional position or to place an ankylosed part in an improved functional attitude. For example, osteotomy may be done to correct a flexion deformity of the knee or wrist. If there is marked subluxation of the tibia, it may increase after osteotomy, although the operation has the advantage that, if there is knock-knee, it may be corrected at the same time.

When joints have become ankylosed and motion is imperative to satisfactory function, arthroplasty or other procedures contriving to develop motion may be done in the quiescent stage. Arthroplasty is most desirable in the hip, knee, elbow, finger, and metatarsophalangeal joints. Although results from operation upon the other joints mentioned are uniformly more successful, some operative procedure to develop motion in the hips is almost imperative when both hips are stiff. Arthroplasty<sup>6</sup> of the hip has become a more dependable procedure than formerly. Pseudoarthrosis as described by Jones may be the elective method of obtaining movement, particu-



larly if an arthroplasty has failed. Occasionally a pseudoarthrosis on one side and an arthroplasty on the other may be chosen as the desirable combination. The result of any operation designed to develop motion in arthritis depends not only on the operative procedure and the postoperative care, but the mental attitude of the patient. In choosing the indicated procedures this must be carefully considered.

Various other measures may be indicated. Synovectomy is occasionally desirable in the knee in instances where the arthritis is quiescent and where there is marked synovial hyperplasia and effusion which is mechanically interfering with function. The original contention that synovectomy may remove a secondary focus of arthritis has not been substantiated. In all operative procedures, after-care and physiotherapeutic measures are as important as the operative procedure itself.

Proper attention to the joints during the acute phase reduces the number of surgical procedures to correct deformities to a minimum.

*Spondylitis Ankylopoietica.* The relationship of spondylitis ankylopoietica to atrophic arthritis is debatable. The spine may be involved alone (von Bechterew) or in association with the shoulders and hips, the so-called spondylitis rhizomelique of Strumpel-Marie. Occasionally other joints of the extremities are implicated in a process similar in all respects to atrophic arthritis. It would seem that the various types of atrophic spondylitis are variations of the same disease, and that they are all related to atrophic arthritis. The unusual calcification of the ligamentous structures and the particular areas affected by the disease suggest other possibilities. Atrophic spondylitis is essentially a disease of the male, appearing in this sex nine times as frequently as in the female.

The disease is characterized by pain in the back with radicular distribution and muscle spasm limiting motion of the spine. There is early loss of chest expansion which

is a diagnostic feature of the disease. Uncontrolled, the spine develops a progressive flexion deformity with marked kyphosis, ankylosis of the spine and ribs, with secondary disturbance of visceral function due to mechanical interference. In the early stages of the disease, roentgenograms show marked atrophy of the involved bones. Later there is fusion of the spine with a typical smooth calcification of the spinal ligaments. The sacroiliac joints are frequently the first joints to fuse.

In those instances when the spine and ribs alone are involved, if deformity is prevented, the spine becomes fused in a good position, diaphragmatic breathing is adequate, the pain disappears, and a very satisfactory functional result is the outcome. Prevention of deformity is accomplished by sleeping on a Bradford frame or a shell of plaster, the use of a long spinal brace, and exercises to combat deformity. If the back is already deformed, and ankylosis is not present, the frame should be bent to follow the maximal correction at the time, and gradually extended as greater correction can be obtained. Occasionally general anesthesia may be given and the spine slowly extended over a period of half an hour by gradually changing the contour of the surface upon which the patient lies. Shells may be applied following. At no time should forced manipulation be used. Where other joints are involved their care is the same as that in atrophic arthritis. "Deep breathing" exercises are very important at all times.

#### HYPERTROPHIC ARTHRITIS

The treatment of the joints in hypertrophic arthritis is best approached by considering the disease as primarily a phenomenon of "wear and tear," possibly associated with vascular changes and disturbed blood supply to the bone subjacent to the cartilage. The articular cartilage becomes thin and fibrillated. There is reaction at the synoviocartilaginous junction with irregular proliferation of cartilage and subjacent calcification, the so-called

hypertrophic spurs. It may be interpreted as a normal degenerative process which appears in varying degrees at variable ages, modified by intrinsic and extrinsic factors. These changes are greatly increased by mechanical strain or previous trauma which interferes with the mechanical efficiency of the joints. They become significant when they are pronounced in degree and provocative of symptoms. In discussion of therapy no distinction will be made between hypertrophic arthritis and chronic traumatic arthritis.

Bothersome symptoms are much more common in the weight-bearing joints for obvious reasons, particularly the spine and the knees. The hips are less frequently implicated, but the most disabling form of hypertrophic arthritis occurs at this site, the so-called *morbus coxae senilis*. Frequently the first visible evidence of the senescent type is the so-called Heberden's nodes adjacent to the terminal interphalangeal joints which are diagnostic of this type of arthritis.

Generally the symptoms are of intermittent type. Marked roentgenographic evidence of hypertrophic change may be unaccompanied by symptoms. The pain is probably associated in many instances with irritation and injury to the synovia at the juncture with the hypertrophic process. The threshold of pain in the particular individual is a factor in the severity of discomfort. When the spine is involved, there may be an associated radiculitis from irritation of the spinal nerves. Symptoms are much more common in obese individuals and where traumatic and mechanical factors are outstanding in the picture.

If the symptoms are acute, the patient must be relieved of discomfort. Rest, heat, massage, and other physiotherapeutic measures are very helpful in this regard. Ordinary radiant heat from an inexpensive lamp using either carbon or tungsten filament is very useful; some prefer diathermy, particularly for the spine. The amount of rest indicated depends upon the

discomfort. Rest need be only temporary. Often proper support to the part is all that is necessary.

The next consideration is that of modifying those general and local factors which are provoking the symptoms. In this instance, obesity becomes a fundamental orthopedic consideration; the more weight, the more stress in weight-bearing joints. Irritation from undesirable mechanical factors must be removed in so far as possible. If the patient has symptoms in the knees, associated with genu valgum, the stress on the joints may be reduced by such factors as a lift to the inner side of the heels of Thomas type, or plates for support of pronated feet, which are frequently an associated finding. The heels of the shoes should be of the correct height, based upon the tightness of the heel cord. Granting that a low heel gives a broad base and would seem to be ideal as far as the stability of the knee is concerned, it provokes irritation rather than relieves it, if the heel cords are tight. Frequently pain behind the knee is relieved by elevation of the heels of the shoes, as may be pain under the ligamentum patellae when hypertrophy of the fat pad exists.

Temporary support to the knees is usually indicated. The simplest is an elastic bandage starting well below the knee and going well above the joint. The efficiency and comfort of such support is increased by a horseshoe of felt extending circularly above the patella and well below the joint line, and a broad flat piece of thinner felt behind the joint. The elastic bandage should be at least 4 inches wide and in large individuals, 6 inches wide. If more than temporary protection is desired, an elastic knee cap of good body going well above and below the knee, split in front with eyelets, lacing, and a tongue of chamois, reinforced with strips of leather at the sides, is a very good method of support. The ordinary short elastic knee cap is of little use. If more rigid protection is desired, such apparatus as the Jones knee cage or any of its modifications, and occasionally a caliper brace



are useful. Frequently it is necessary to add a single caliper upright to the shoe in the "cage type" of brace to keep it in position. The support of the knee under normal circumstances is largely dependent upon the quadriceps muscle. Although extreme muscle atrophy is characteristic of atrophic arthritis, not hypertrophic, any painful lesion of the knee causes a reflex atony of the quadriceps and secondary atrophy. To restore the functional capacity of the knee, the quadriceps must be returned to its normal power.<sup>3</sup>

The simplest method of developing quadriceps power is "setting" the muscle with the knee in extension. This must be done on a regular schedule and to a point of just approaching fatigue. Massage and other exercises which do not induce pain or trauma are helpful. Walking with a weak quadriceps does not increase its power, if it is unable to carry out its function. It merely increases the disability.

In arthritis of the spine, support is frequently indicated in the form of a back lace corset or a brace, either of "low back" type or a long spinal brace, depending on the site and extent of the process. Postural factors which are producing strain should be corrected. In postural training the first step is to teach the individual how to assume a better posture. In practice the best approach is to have the individual stand against the wall with his feet a few inches from the baseboard, and teach him to tilt his pelvis by retracting his abdomen and contracting his gluteal muscles. Often the contraction of these particular muscles is taught better in the recumbent position before assuming the erect one. As soon as the back can be flattened the individual shifts from the wall, retaining the desired position. This is repeated until he can assume a good attitude independent of the wall. He is then allowed to relax his gluteal muscles and walk with his abdomen retracted, gradually eliminating the tenseness which exists at the start. Accessory exercises are given to strengthen the abdominal and gluteal muscles as indi-

cated. In lesions of the cervical spine, stretching with heavy traction combined with radiant heat and massage is very helpful. Occasionally a Thomas collar may be used.

*Morbus Coxae Senilis.* Severe hypertrophic arthritis of the hip with deformity of the head of the femur, so-called morbus coxae senilis, is one of the most difficult lesions to relieve. It is particularly bothersome if both joints are involved. The hip develops a flexion-adduction, external rotation deformity with marked limitation of motion and pain in the hip and the knee.

Various conservative measures of simple type may give considerable relief. A raise to the heel on the involved adducted side balancing the apparent shortening may change the apposition of the weight-bearing surfaces and relieve trauma to the hypertrophic spurs. Non-traumatizing exercises should be given to strengthen the abductors and extensors of the hip, particularly in the form of muscle-setting exercises.

Rest, of course, is an essential agent. Occasionally being off the feet for a few days allows a subsidence of symptoms so that other conservative measures are effective. The temporary use of crutches or a cane is often indicated. Occasionally traction at night, using a removable stocking held by an elastic bandage with weight on a pulley over the foot of the bed, is useful. Removable spicas may be indicated for support.

*Operative Procedures.* Except in the case of the hip, operative procedures are not often indicated in hypertrophic arthritis. In the hip acetabuloplasty<sup>7</sup> with excision of the anterior capsule may give relief and is particularly helpful where the condition is bilateral. Some form of arthroplasty may occasionally be desirable. In instances where the lesion is unilateral, fusion of the hip may be the procedure of choice.

Occasionally a particular hypertrophic spur may warrant excision. Such a process was one on the coronoid process of the ulna which impinged on the head of the radius with considerable pain and dis-

ability. Removal gave complete relief from symptoms. Various other procedures may be indicated depending upon the condition present: removal of joint mice, synovectomy for so-called villous arthritis, and so forth. Rarely is it desirable to fuse a spine, and, in general, surgery does not have any considerable place in the therapy of hypertrophic arthritis except in the hip joint.

#### MISCELLANEOUS CONDITIONS

In addition to the two major types of chronic arthritis, consideration must be given to various other lesions of the joints and diseases simulating arthritis. In many of these conditions there is disagreement in the literature both as to the terminology that should be employed and the type of pathologic process present. The terms arthralgia, neuralgia, neuromyositis, fibrositis, toxic arthritis, all come in this category. What might be called "toxic arthritis" by one clinician, might be called "fibrositis" by another, or "arthralgia," which is merely saying there is pain in the joint, by still another. The actual disease in certain vague intermittent pains referable to joints is not determined. Certain conditions are definite in type as determined by the etiologic factor or the pathologic process and local manifestations. Among these may be listed tendinitis, bursitis, traumatic arthritis, gonococcal, syphilitic, and hemophilic arthritis. Idiopathic hydrarthrosis may be questionably included in such a group.

In all instances of symptoms in joints and extremities of doubtful type, particular attention must be given to mechanical factors which may enter into the picture. Pain in the feet is more commonly due to foot strain than other causes. Contracted gastrocnemii may provoke pain in the calves and knees. Contracted fascia lata and posterior structures of the thigh may incite pain in the lower extremities and back. Postural factors are the most common cause of backache. These and other

possibilities must be analyzed before the diagnosis is made.

At the present time we classify a certain number of joint manifestations which we cannot otherwise differentiate under the term "toxic arthritis," realizing that it is a very questionable group. We include under such a tentative diagnosis, involvement of a single joint or a few joints with definite physical findings and occasionally instances of multiple joints with few positive findings. Certain of these are mild or early instances of atrophic arthritis and this possibility is always considered. They should be treated as atrophic arthritis if the general picture, the clinical examination, and the laboratory findings are in any way suggestive. Rheumatic fever and other clinical entities are likewise considered before placing the individual in this tentative group. It is realized that as our knowledge of arthritis increases, cases will be removed from such a "grab bag" as toxic arthritis and accurately classified.

Under this heading we place the arthritis of children which involves a single joint, and occasionally two or three joints, which does not materialize into generalized atrophic arthritis, although it may be an atypical manifestation of the latter. Such a disease is relatively common in children. At the Children's Hospital, Boston, during the past ten years, arthritis of a single joint has been found to be much more likely of nonspecific than tuberculous origin.

It is suggested in many instances that focal infection or intestinal disturbances are related to these joints. However, we avoid the term infectious arthritis in such instances, as this would merely confuse this type with outspoken atrophic arthritis. We would suggest, however, that the use of the term infectious arthritis is more nearly applicable in many of these patients than its more common use as synonymous with atrophic arthritis.

Therapeutically the care of such joints, after general measures such as attention to focal infection, dietary régime, and bowel management, depends upon the

local manifestations. If the process is quite acute, as frequently is true in children, relief of spasm and deformity by traction, physiotherapy, with particular emphasis on guided active motion, and immobilization in the corrected position by bivalved plaster casts are basic features of therapy. Occasionally the recovery is slow, but ordinarily complete. A weight-bearing splint may be desirable in the convalescence of a joint of the lower extremity. It is interesting that when the process is prolonged in children, stimulation of longitudinal growth occurs. This is most striking when the knee joint is involved and may amount to  $\frac{3}{4}$  of an inch. When weight bearing is started, increased length must be recognized and the shoe of the opposite side raised; otherwise there is a recurrence of the flexion deformity.

In milder types, rest, a removable well fitting support, and physiotherapy are helpful. Immobilization at night may likewise be desirable.

*Fibrositis.* How often such a disease occurs is not agreed. There are those who believe it is the common cause of transient joint and "near joint" pains. They interpret acute torticollis, lumbago, and other similar disturbances on such a basis. The presence of symptoms which might be interpreted as fibrositis demands a careful examination of the spine as well as an evaluation of other mechanical factors which might explain the picture.

Using the term fibrositis broadly, we may include such common entities as tendinitis, tenovaginitis, and bursitis, which frequently are confused with arthritis. Tendinitis, which is frequently of the calcareous type, and bursitis may occur in many locations, but the classical site is about the shoulder; the most common tendon involved is the supraspinatus,<sup>8</sup> the most common bursa, the subdeltoid. In cases with acute symptoms, severe pain, which is made excruciating by abduction and rotation, is typical, with point tenderness over the greater tuberosity. The pain is referred over the deltoid

tubercle of the humerus. Milder cases show less discomfort, emphasized by abduction and the extremes of rotation. At the onset of acute symptoms, a calcareous deposit may not be demonstrable by roentgenograms, although frequently it is present at this time, indicating that the process is of longer duration than the symptoms suggest. The pathologic process is one of degeneration of the tendon with the presence of a thick calcareous material, and in the acute stage, surrounding inflammation of nonspecific type. The etiology is unknown. Trauma is usually given as an etiologic agent, but other unknown factors must exist. It is common for the same individual to have multiple lesions.

The treatment may be conservative or operative. Conservative therapy consists of the use of a sling in a comfortable position, heat which may be dry or moist (dry heat may increase the pain occasionally), and gentle pendulum motions of the hanging arm with the patient standing in a stooped position. These motions should be quite gentle and active, not passive, emphasizing abduction, rotation, and flexion. In carrying out motions in the stooped position, forward flexion of the humerus approaching a right angle exists at the start, and movements are carried out with surprising ease. To appreciate the position of the arm with regard to the shoulder girdle, it is only necessary to hold the arm in a constant position relative to the scapula and have the individual extend his spine to the erect position. Although rest is the primary therapy, carrying on motion in this fashion is important as otherwise the associated peri arthritis may give rise to a painful fixed shoulder.

Frequently operative procedures are indicated. Of these, irrigation with a solution of normal saline using a two needle technique is simple and has been very effective. This method, as evolved by Smith-Petersen and Norton<sup>9</sup> and described by Patterson and Darrach,<sup>10</sup> consists in introducing two large caliber needles, 16 gauge, into the

calcific deposit, forcing the saline under pressure into one needle, which in turn forces the calcific fluid out the other. In a great number of cases in which the symptoms are acute, a considerable portion of the deposit can be thus evacuated. The relief may be immediate and dramatic. Frequently, however, the patient remains quite uncomfortable for forty-eight hours with quite rapid recovery thereafter. In many instances the material cannot be evacuated, in which case the area is repeatedly perforated with the needle and saline forced into the site under pressure to the extent of perhaps 40 to 75 c.c. The arm is then carried through a full range of motion at the shoulder. In these patients the relief is not so striking as where a considerable portion of the material is removed, but it is nevertheless definite. In view of the improvement where the material is not actually removed, it would seem that the necessary mechanism in giving relief is needling and rupturing the wall surrounding the calcareous deposit, thus reducing the tension, and allowing absorption of the substance. In one instance about one-third of the deposit was removed as estimated by roentgenograms. Three weeks later the patient died of an unrelated disease. Examination of the shoulder at that time showed only a tiny deposit remaining and the whole process healing. He had obtained dramatic relief from the irrigation and was back at his work as a dentist five days after the operative procedure. The irrigation may be done under local anesthesia, but it may be more desirable to use a general anesthetic.

The postoperative care in these patients is important and consists essentially of that outlined under conservative treatment. We do not fix the arm in abduction, as it increases the postoperative discomfort; a sling is used for support.

In "frozen shoulders" where the peri-arthritis has given rise to firm adhesions, manipulation under anesthesia is frequently desirable. The injection of saline in the involved plane, to a point where the

deltoid muscle is outlined by the subjacent solution is a good preliminary measure. In the manipulation, the shoulder is carried through a full range of motion, but it must be done carefully, as the humerus can be broken if the bone is atrophic and the adhesions are firm. It appears that the instillation of saline renders the manipulation easier, and the postoperative course less painful, perhaps by the infiltration of the injected saline and the subsequent distention of the tissue spaces. After manipulation, the arm should be placed in abduction and exercises of active type started early. At best these patients have considerable postoperative distress.

Although general anesthesia is almost imperative, if desired, the injection may be done using local anesthesia following which a brief general anesthesia such as evipal may be given for the manipulation.

The other operative procedure available is incision and evacuation of the calcareous material. This procedure is simple and has the particular virtue that indefiniteness is obviated and the process can be seen and the material removed. In our experience, in an acute process, irrigation gives just as prompt relief and shorter convalescence. If the irrigation does not relieve symptoms after an adequate interval, open procedure is indicated.

*Gonococcal Arthritis.* Gonococcal arthritis may be of frankly septic type in which the organisms can be obtained by smear and culture. In others the organisms cannot be demonstrated and the actual etiologic mechanism is in doubt. The latter type is less severe and more likely to involve multiple joints.

The orthopedic care of gonococcal arthritis has assumed much less importance since medical care has become more effective. Previously, an effective method in those in which the organism could be demonstrated was incision of the joint, irrigation with warm saline for twenty minutes with closure of the joint followed by appropriate after-care. Such care was a combination of immobilization in the

elective position, by either a half-cast of plaster, or preferably by counterpoised traction if the particular joint allowed itself to such traction. Gentle guided active motion, heat, and other definitive types of physical therapy were given as indicated.

The local care of the non-septic type of gonococcal arthritis was essentially the same as that used in the after-care of the septic joint. Immobilization in a position of election with guided active motion each day, and local heat were essential considerations.

With the use of fever therapy of efficient type and sulfanilamide, orthopedic measures have become less important, and surgical procedures in septic gonococcal joints are not ordinarily indicated. However, immobilization in a position of election and guided exercises for the restoration of function of the joint remain important factors in the treatment.

*Syphilitic Arthritis.* Arthritis from syphilis may occur in either the secondary or tertiary stage. Synovitis due to syphilis is most common in the congenital disease, and the knee is involved most frequently. It is often bilateral. The idea that it is always painless cannot be verified as occasionally the joint may be quite sensitive. The treatment is support as indicated by the distention of the joint and the sensitivity, combined with the specific treatment for syphilis.

Charcot's joint, with disintegration of the joint, pronounced proliferative reaction of the bone, and singular lack of pain is really a neuropathic arthropathy. Adequate support to the part combined with antiluetic therapy is the treatment of choice. Occasionally intrinsic fixation of a given joint is indicated, although it may be difficult to obtain fusion. In certain instances amputation may be desirable.

*Hemophilic Arthritis.* Repeated hemorrhage into a joint causes marked distention of the capsule, irritation of the synovia with subsynovial scarring and destructive lesions in the subchondral bone with involvement

of the cartilage as described in detail by Key.<sup>11</sup>

The joints should be protected during the acute phase, in which the capsule is markedly distended, by immobilization and pressure with an elastic bandage. A posterior shell of plaster is an ideal method of immobilization, with loosening and tightening of the bandage as indicated. Occasionally if the capsule is markedly distended, and the clotting time is not too long, the joint may be carefully aspirated with a fine needle. The needle should be directed obliquely through soft tissues in approaching the joint.

Repeated hemorrhages produce a chronic arthritis with deformity which may be very similar in appearance to the result of atrophic arthritis. Gentle correction of deformities by conservative means and exercises for those muscles opposing deformity may be indicated. Extrinsic support to the joints is occasionally advisable.

*Idiopathic Hydrarthrosis.* In this condition, the joint is distended by an excess amount of synovial fluid, with singularly little synovial thickening, and usually little or no sensitivity, unless the distention is extreme. Frequently it is intermittent in type (intermittent hydrops) and on a fairly regular schedule both as to duration and interval. It is more common in women. The knee is most often involved. The etiology is unknown, although various theories have arisen, including ideas that it is related to angioneurotic edema, that it is due to an endocrine disturbance, and that it is an allergic phenomenon.

With distention of the joint and secondary relaxation of the capsule, secondary traumatic arthritis may arise. Support and pressure during the acute phase, using an elastic bandage or knee cap, may be helpful, and undesirable mechanical factors should be corrected. Exercises to the quadriceps in the instance of the knee should be stressed. In particularly bothersome cases, synovectomy may be desirable. In swelling of the continuous type, lues should be considered in the differential

diagnosis, as should synovial tuberculosis and other forms of arthritis.

*Traumatic Arthritis.* Arthritis due to chronic trauma of mechanical and static nature has been considered under hypertrophic arthritis. The treatment of chronic traumatic arthritis, which is the residuum of severe acute injury must be individualized and approached with a consideration of principles previously discussed.

#### LOW BACK PAIN—SCIATICA

A discussion of this subject requires more space than can be given here. Of proved arthritic entities, atrophic, hypertrophic, and traumatic arthritis may produce pain in the back, with or without sciatic radiation. The actual mechanism of pain in many instances is in doubt, but ligamentous strain and irritation of the apophyseal joints by disease or trauma must be the mechanism in many instances. The importance of referred pain is emphasized by some, particularly with regard to the sacroiliac joints. Fibrositis and myofascitis are likewise suggested as the cause of many pains in the back, but the exact relationship and incidence of such a condition has not been established. Neither has the importance of "articular slips" been proved. Postural and mechanical strain is probably the greatest factor in backache.

Anything which irritates the nerve either in the spinal canal, in the intervertebral foramina, or elsewhere in its course may cause pain with a sciatic distribution. Hypertrophic arthritis or other narrowing of the intervertebral foramina, particularly that through which the fifth lumbar nerve passes, may cause a radiculitis. Hadley<sup>12</sup> has recently affirmed embarrassment of the nerve by subluxation of the apophyseal articulations associated with narrowing of the intervertebral disk.

The relationship of lesions in the spinal canal to pain of sciatic radiation has been emphasized in recent years by Barr,<sup>13</sup> Mixter, and others. Protrusion of tissue

from the intervertebral disc may impinge on one or more nerve roots of the cauda equina, producing "sciatica." Likewise, others have pointed out that hypertrophy of the ligamentum flavum<sup>14</sup> may produce a similar picture. These lesions must be suspected in intractable "sciatica."

A thorough attempt should be made to explain the origin of the symptoms with full consideration of the history as well as the physical findings. All mechanical factors must be evaluated both in the back and in the lower extremities. What are the characteristics of posture as they affect the back? Does a significant anomaly of the spine, such as spondylolisthesis, exist? Is one leg shorter than the other? Are the feet pronated? Are the fascia lata and the posterior structures contracted? May the lesions be localized by manipulative measures or palpation? What neurological signs are present? Complete roentgenographic study of the lower spine is necessary. Spinal puncture may be desirable with determination of the total protein and dynamics. Visualization of the spinal canal may be indicated.

The relationship of backache to fatigue, poor health, and other lesions remote to the back must be kept in mind.

Conservative measures are ordinarily indicated before other procedures are considered. If the pain is severe, absolute rest on a firm straight bed with pillows under the knees and physiotherapeutic measures are essential. Support in the form of a back-lace corset, a low back brace, or even temporary strapping with adhesive plaster is most helpful. Usually, if sciatic radiation is present, a corset is more useful than a brace. Postural exercises, particularly abdominal and gluteal setting, aid in most instances, as emphasized in the section on hypertrophic arthritis. In fact, adequate support and attention to posture form the basic treatment of the greater number of patients with back pain.

If in "sciatica," the fascia lata is contracted, division may be done, as advocated by Ober,<sup>15</sup> under local anesthesia with

little bother to the patient and in a considerable percentage with marked relief.

We believe that these measures should be tried before more radical procedures are considered including the introduction of lipiodol into the spinal canal to visualize a possible herniation of the disc, unless the protein of the spinal fluid is markedly elevated or the signs are very striking.

#### SUMMARY COMMENT

Attention to the joints is a basic consideration in all types of arthritis. The local measures are dictated by the type and phase of the disease.

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# CORRECTION OF CONGENITAL DEFORMATIONS OF THE HAND

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THE surgeon who is confronted with the problem of correcting congenital deformity of the hands is faced with several perplexities; although the diagnosis in most instances may be a simple matter, in the presence of some of the vascular anomalies, diagnosis and treatment will tax the astuteness of those concerned. The surgeon must keep foremost in his mind two problems: (1) that of function and (2) that of appearance. Function should not be sacrificed in order to improve appearance; each case must be considered individually.

It is difficult to make a practical classification of congenital malformations of the hand because of the multiplicity of such conditions, their many combinations and the prevalent lack of knowledge as to their etiology and pathology. Therefore, in this communication terms which are descriptive of the morphologic characteristics will be used.

The basic approach to the study of these congenital malformations is through etiology. Hypotheses too numerous to mention in a paper of this kind have been put forth. Similar congenital malformations of the hands and feet frequently are encountered in examining the same individual; this fact, together with the high incidence of a history of similar malformations in forebears, suggests the possibility that the germ plasm hypothesis of origin of the condition is correct. The work of Bagg demonstrated that congenital deformities may be produced by insult to the germinal cells, that these deformities may manifest themselves in the progeny. In his work mice were subjected to Roentgen irradiation and various anatomic defects of the extremities were inherited by the descendants.

Because of limitation of space, material relative to anomalous vessels, nerves and muscles will be omitted from the following discussion.

## SYNDACTYLIA (WEB FINGERS)

As was mentioned earlier, congenital malformations of the hand frequently are seen in association with other anomalies. This is particularly true of syndactylia. Various degrees of webbing of the fingers are found, the union consisting of skin only, of skin and fibrous tissue or of fused bony elements. Anomalous vessels, nerves, joints, tendons and tendon sheaths also are encountered and the various components of the anomaly are to be considered before surgical operation is undertaken.

Numerous operations for the correction of syndactylia have been described, the earlier procedures being directed only at severance of the web. The technique of each of the earlier procedures was based on principles of surgery current at the time the procedure was in favor.

The problem arises as to when operation for syndactylia should be performed. If the web is a simple one that was noted at birth, and distortion of the involved fingers is not present, it is advisable to wait until the patient is older; this will greatly simplify the technical difficulties encountered. However, if the syndactylia is of more severe degree, and considerable deformity already is present, then the end results might be improved by operative intervention in the first year of life, with the understanding that secondary plastic operations are carried out more satisfactorily at a later time. Space does not permit review of the merits of the many operative procedures for correction of syndactylia



which were described by Rudtorffer in 1901, Zeller in 1810, Didot in 1850, Agnew in 1883, Felizet in 1892, Tubby in 1912,

To cover the commissure with skin so that a scar will not form is one of the important principles which should be kept

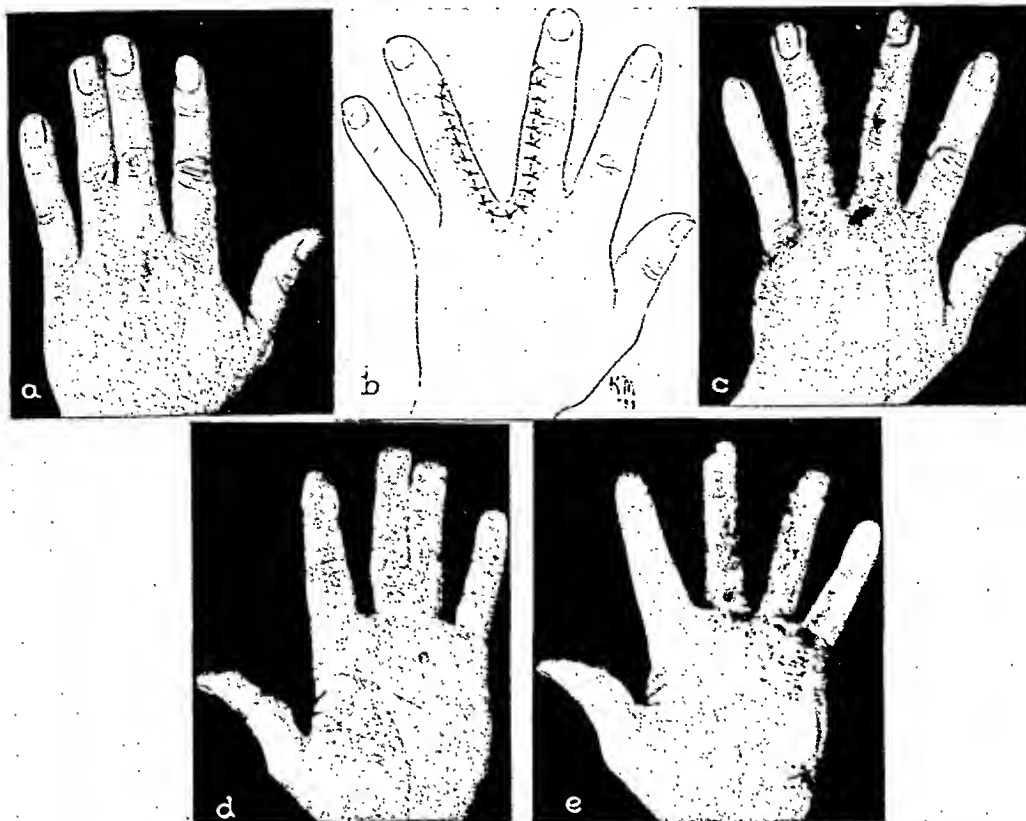


FIG. 1. *a*, dorsal view of left hand showing webbing of middle and ring fingers before surgical intervention. *b*, separation of fingers and split skin graft sutured over denuded surface. *c*, dorsal view immediately after removal of stitches. *d*, palmar view of hand before operation. *e*, palmar view immediately after removal of stitches.

Faniel in 1911, Rudulesco in 1923 and Ville Chaise and Jean in 1927, but in their time many of the authorities named improved the technique of surgical treatment of this condition.

Plastic procedures may be used in some of the more simple cases of syndactyly. In the more severe cases, however, no matter what operative procedure is selected, when the web is severed the available skin is inadequate and application of a skin graft is necessary. The extensive scar which followed the older operative procedures also permitted recurrence of the web and other unfortunate sequelae, such as contractures. Some of the older procedures, such as Didot's plastic operation (1850), have been known to result in gangrene of the fingers in those instances wherein the blood vessels had been divided in raising the skin flaps.

in mind. When more than two fingers of one hand are involved, it is best to carry out only one procedure at a time. Kanavel advocated the use of full thickness skin grafts, but the split skin graft method of Blair and Brown has given satisfactory results in our hands.

**CASE 1.** A man, aged 30 years, stated that a deformity of his left hand had been present since birth. In an attempt to separate the third and fourth fingers, the web was cut and a flap made on the dorsum of the third finger; a flap also was raised on the volar surface of the fourth finger. These flaps were not large enough to cover the defects and the remaining areas were covered with a split skin graft, which had been taken from the left thigh. The grafts were sutured into place with fine black silk and were perforated with a sharp knife. The wounds were dressed with scarlet red ointment gauze

and a sea sponge dressing was applied to exert pressure. The functional result following this procedure was excellent. (Fig. 1.)

again difficulty is encountered because of the multiplicity of abnormalities. A marginal and a central type can be identified.

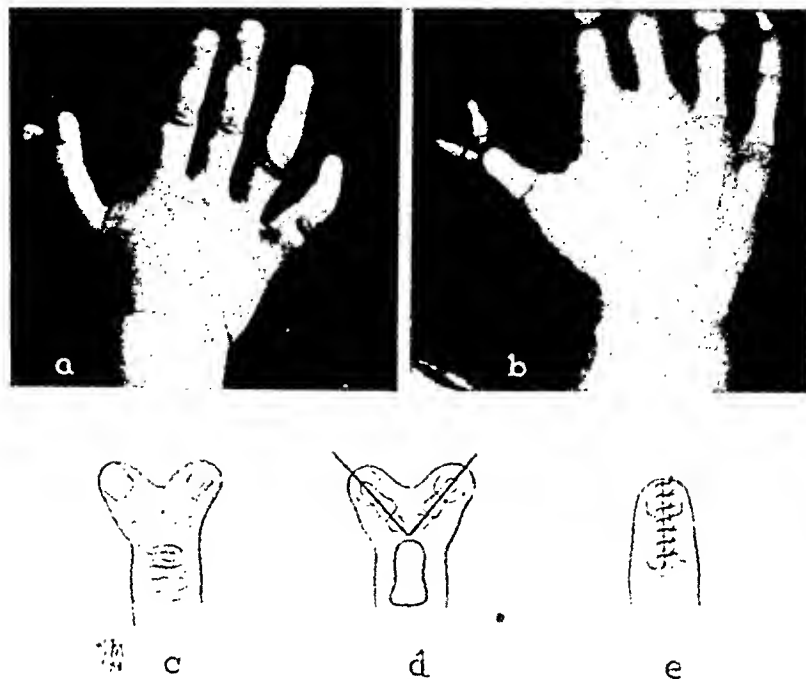


FIG. 2. *a*, dorsal view showing bifid thumb. *b*, roentgenogram showing the two terminal phalanges. *c*, bifid thumb. *d*, wedge-shaped excision through distal phalanges and soft parts. *e*, closure of wound with approximation of the halves of the digit.

In cases of terminal bony syndactylia, division of the terminal phalanx and repair by skin graft is the desirable procedure. Extreme care must be given the blood vessels and nerves because they are often anomalous. The tendons to each finger should be examined carefully and, in the event one or the other tendon is deficient, judgment should be exercised in determining to which finger the tendon should remain attached. A plastic procedure can be carried out later on the digit which is lacking a tendon. Attention must be given to the nails, joints and deficient muscles. Simple division of a fused nail can be carried out along with division of the phalanx. Simple division of the terminal interphalangeal joint does not seriously interfere with function.

#### POLYDACTYLISM (SUPERNUMERARY DIGITS)

Many attempts have been made to group the various types of polydactylism, but

The marginal form, characterized by duplication of the thumb or little finger, is most common. The condition may arise from bifurcation of the metacarpal bones or merely from bifurcation of the phalanges, in which event syndactylia is an associated condition.

Polydactylism is not infrequently encountered in combination with syndactylia and, more rarely, with lack of development of some portion of the hand. Polydactylism is often bilateral, frequently involves both the hands and the feet and often is associated with other congenital anomalies. The extra digit is usually very atypical in its form and components; the bony components may be duplicated, fused or distorted. Its blood supply, nerves, tendons and joints are often abnormal.

Before any surgical procedure is carried out careful consideration must be given to preservation of function. Due attention must be given to the insertion of tendons

and to the vascular and nerve supply to a part.

An extra digit on the thumb may be

are brought together in the median line. The incision may be modified some if one rudiment is longer than the other. (Fig. 2.)

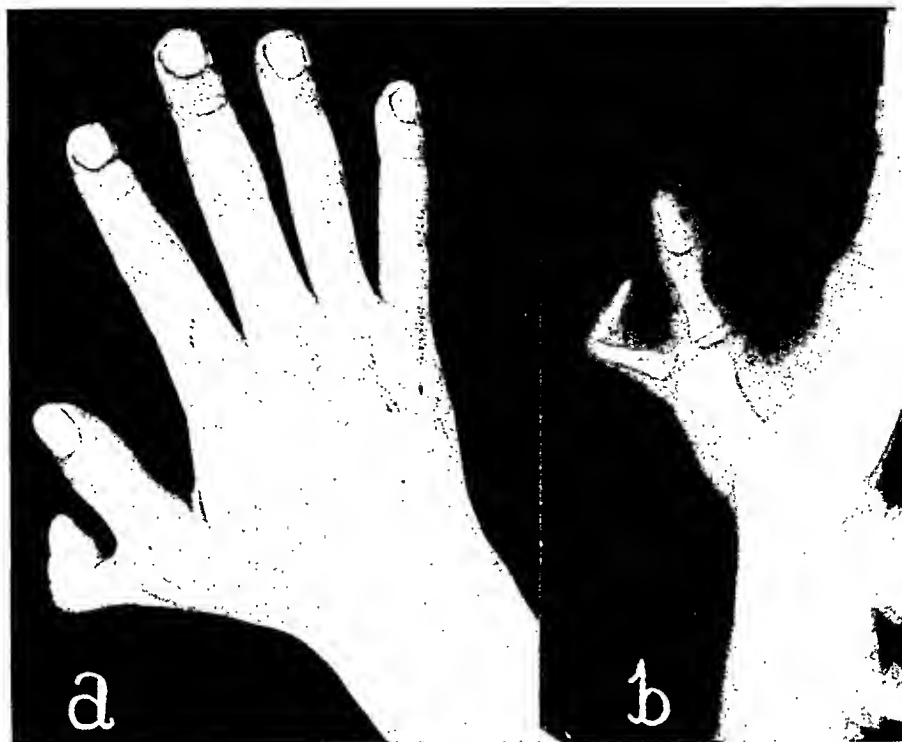


FIG. 3. a, dorsum of right hand, showing accessory thumb (polydactylysm). b, roentgenogram showing two phalanges in the accessory thumb.

better left alone. Any corrective surgical procedure here, without careful consideration, may disturb the circulation and result in gangrene of the remaining digit. Particular attention should be given the intrinsic musculature of the thenar region, as operative procedures might result in a flail digit. It may be best for maintenance of function to transfer the tendon from the extra digit which is to be removed to the remaining digit or even to other portions of the hand. Simple hypoplastic digits are best amputated. The Bilhout-Cloquet plastic procedure has the advantage, in caring for bifurcated distal phalanges, of preserving the attachment to the tendon. This procedure is particularly applicable to the thumb in cases in which a v-shaped median section is removed from the two parts. The incision extends from the middle of the distal part of one rudiment, down below the bifurcation, and back distal to the middle of the other rudiment; the intervening components are removed and the remaining portions of the two rudimentary phalanges

CASE 11. A boy, aged 8 years, complained of an accessory thumb of the right hand, which had bothered him only in a mechanical way. (Fig. 3.) The accessory thumb was amputated at the metacarpophalangeal joint and both appearance and function were improved.

#### ECTRODACTYLIA (CLEFT HAND, LOBSTER CLAW HAND, CRAB CLAW HAND)

The classic type of lobster claw hand is one without the middle finger and part of its metacarpal bone. Many would limit the term to this lesion. However, every degree of involvement is found; that is, the middle finger alone, or the middle finger and its metacarpal bone, or all components of the middle portion of the hand may be absent. Rudimentary phalanges and metacarpals, of various degrees of development, may be noted.

Various types of plastic procedures can be performed on patients with this condition and considerable improvement of both appearance and function may result. The improvement in function depends considerably on the extent of involvement of

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nerves, muscles, tendons and joints. Thus, in cases of ectrosyndactylia, if some digits are absent and those remaining are fused, joint. If the condition is recognized early in life correction can be accomplished by application of proper splints. The more

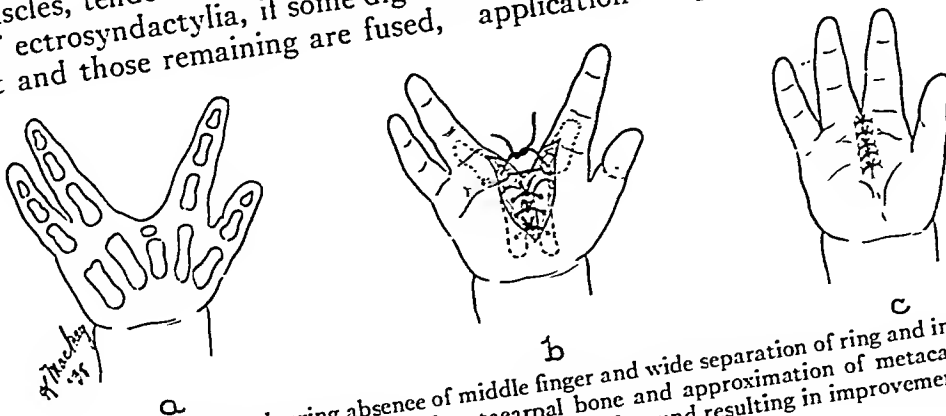


FIG. 4. a, claw hand, showing absence of middle finger and wide separation of ring and index fingers. b, excision and removal of metacarpal bone and approximation of metacarpal bones by means of three sutures. c, approximation of wound resulting in improvement in appearance of hand.

surgical treatment may be contraindicated because of malformation of the component parts.

Operative procedures in these cases are best carried out in several stages. The primary object is to approximate the fingers on the radial and ulnar sides of the hand. If the cleft extends into the palm of the hand, a wedge-shaped incision is made, extending from the middle of the proximal phalanx down through the palm of the hand. After the deeper structures have been exposed by dissection, it may be necessary to resect any anomalous bony fragments in order to permit closer approximation of the adjacent metacarpal bones. The metacarpals and proximal ends of the phalanges are bound together with living suture material such as fascia lata or with some nonabsorbable suture material, and then the tissues are approximated layer to layer. (Fig. 4.)

In those cases of lobster claw hand in which the cleft does not extend into the palm, and the index finger is entirely separate from the thumb, this finger can be transplanted as described by Kanavel.

#### CLINODACTYLY, DACTYLOGRYPOSIS (FLEXION OF FINGERS)

Clinodactyly is thought to result from some disturbance in the epiphysis, producing malalignment in the interphalangeal

severe conditions, seen later in life, necessitate division of the shortened bands of fascia, possible lengthening of tendon and filling in of the defect by a split skin graft. Congenital contracture of the finger, seen late in life, should not be confused with Dupuytren's contracture. (Fig. 5A and B.)

#### MEGALODACTYLIA, MACRODACTYLY (GIANT FINGERS)

Hypertrophy of the digits, a rare entity, usually affects the thumb, index finger or middle finger. Giant fingers result from one of two causes: (1) bony overgrowth; and (2) lymphatic and neurofibromatous hyperplasia. If the cause of the anomaly is the type of hyperplasia that has been mentioned, usually an abundance of fatty tissue is present; if the cause is bony overgrowth, there is little or no change in the soft tissues. In the presence of neurofibromatous hyperplasia, the digital nerves have been known to reach 8 mm. in diameter.

If the overgrowth is a result of neurofibromatous tissue, a plastic procedure, in the course of which the hyperplastic tissue is removed, can be carried out in an attempt to improve the appearance of the hand. When the giantism is a result of bony overgrowth, as well as of hypertrophy of the soft tissues, both function and appearance of the hand can be improved by amputation.

CASE III. A man, aged 28 years, complained that the left ring finger had been enlarged since birth and that the left index and middle fingers

of the pathologists was as follows: "The specimen consists of a finger 13 cm. in length and 2.5 cm. in diameter, characterized for the most

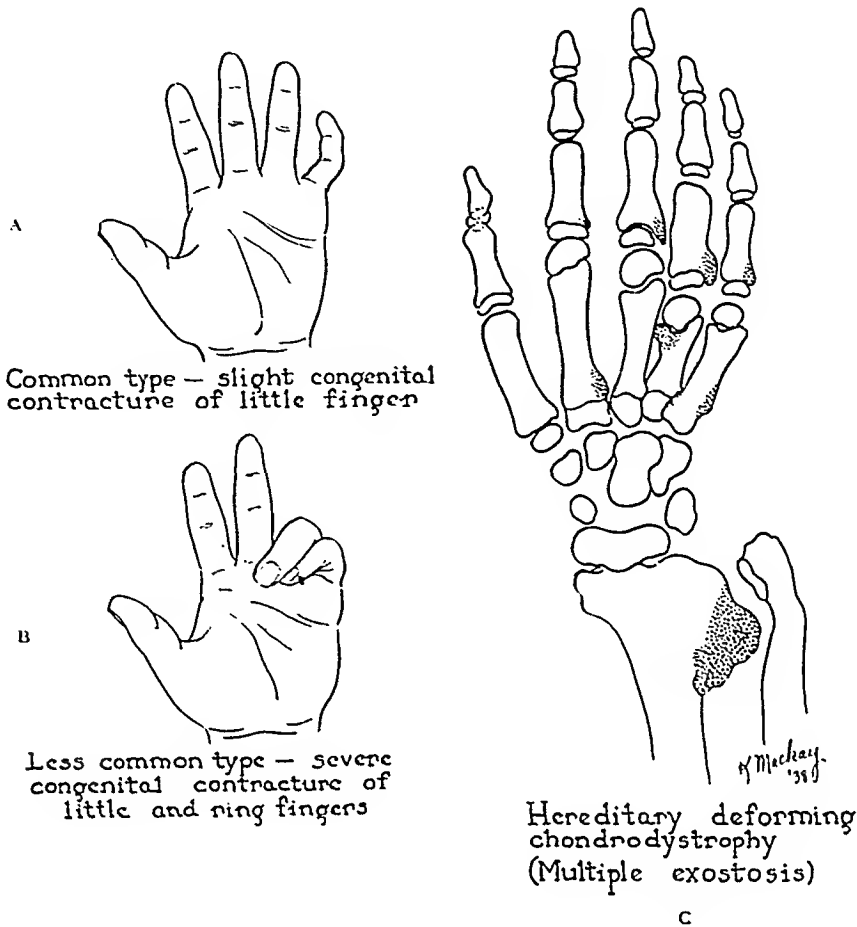


FIG. 5. Congenital flexion of fingers and hereditary deforming chondrodystrophy (multiple exostosis).

were weak. The family history was negative. General physical and laboratory examinations gave negative results except for the following findings relative to the left hand and forearm: In addition to the enlarged finger, represented in Figure 6A, in the palm of the hand there was a palpable mass which extended into the forearm. Neurologic investigation of the hand revealed both motor and sensory changes consistent with inflammation of the median nerve. The anteroposterior roentgenograms of the hand revealed hypertrophy of the phalanges with evidence of destruction in the interphalangeal joints. There was also exostosis on the ulnar side of the middle phalanx of the middle finger. (Fig. 6B.)

At operation the mass on the flexor surface of the wrist proved to be a neurofibroma; neurolysis was carried out and the wound closed. The giant finger then was amputated at the metacarpophalangeal joint. The report

part by a marked increase of fibrous and fatty tissue, also hyperkeratosis of the palmar surface of the epidermis. The digital branch of the median nerve on the radial side showed a fusiform neuroma, 3.5 cm. in length and 8 mm. at its greatest diameter, beginning opposite the proximal interphalangeal joint."

#### CONGENITAL ARTERIOVENOUS FISTULA

Arteriovenous fistula was first described by William Hunter in 1757, when he discussed the clinical features and the disturbed vascular physiologic processes which accompany the condition. Horton<sup>8</sup> has defined an arteriovenous fistula as any abnormal communication between an artery and vein, by means of which arterial blood passes from an artery to a vein without passing through a capillary bed.

Congenital arteriovenous fistulas always have been considered rare. In 1920, Callander reviewed 447 reports of cases of

seen more often in association with the acquired forms of arteriovenous fistula, occasionally they are seen in the presence

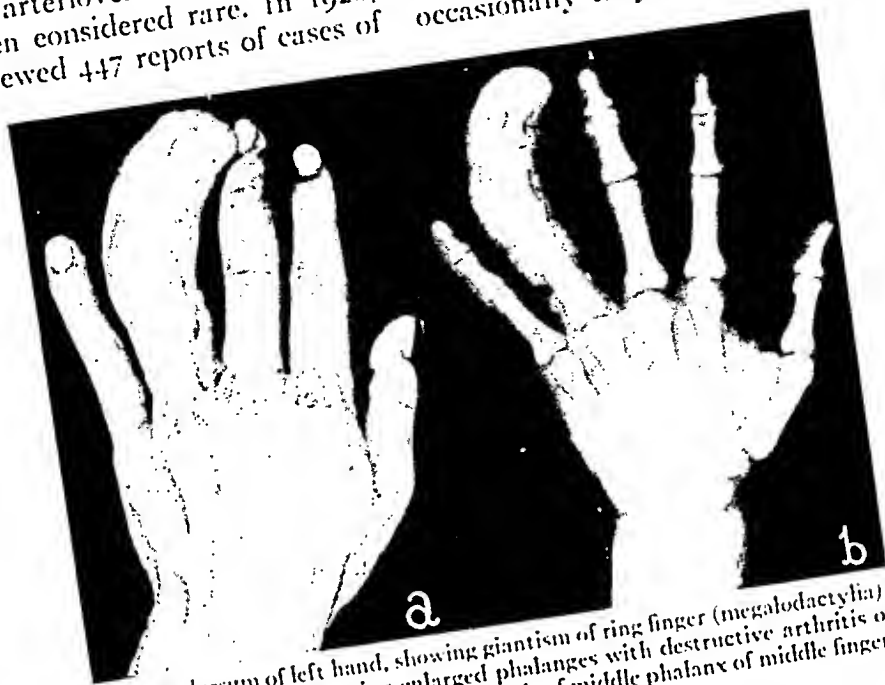


FIG. 6. *a*, dorsum of left hand, showing giantism of ring finger (megalodactylia). *b*, roentgenogram, showing enlarged phalanges with destructive arthritis of interphalangeal joints and small exostosis of middle phalanx of middle finger.

arteriovenous fistula and found only three records of the congenital form. In 1930 Lewis, in reviewing the literature, was able to find reports of only thirty cases, including the six of his own. From June, 1929 to May, 1931 twenty-four patients with arteriovenous fistula were seen at The Mayo Clinic and reports of their cases were made. That this number of cases was encountered in so short a period would suggest that diagnosis has been improved by adoption of newer methods.

The primary step in management of any aneurysmal swelling depends on first establishing a diagnosis. In the involved extremity, usually the veins are engorged and the blood pressure is increased; moreover, the extremity usually is larger and warmer than the opposite one. Horton<sup>9</sup> has shown by arteriography that if the involved extremity is longer than the normal one the fistula usually is near an epiphysis. In some instances the bones may be involved. Bruits or thrills may or may not be present. While profound changes in the hydraulics and physiology of the vascular system are

of congenital arteriovenous fistula. The diagnosis can be confirmed by determination of the oxygen saturation of the blood, as described by Brown, and by arteriography. In the past the treatment of congenital arteriovenous fistula has been unsuccessful. Lewis (1930) reported thirty cases, in twenty-seven of which the condition occurred in the extremities; of these twenty-seven patients, thirteen ultimately came to amputation.

We have found satisfactory the following technique for roentgenographic demonstration of arteriovenous communications in the hand. With the sphygmomanometer used as a tourniquet, 10 c.c. of a colloidal suspension of thorium dioxide (thorotrast) is injected into the brachial artery through a needle of small gauge. If serial roentgenograms are made immediately, often it is possible to demonstrate the flow of medium from arterial to venous tree through one fistula or more than one. This is of great importance to the surgeon, as it demonstrates the number, extent and situation of abnormal arteriovenous communications.

Cases have been reported by Horton and Ghormley and by Meyerding and Horton,<sup>11</sup> one of which is herein described again.

after the operation the systolic blood pressure in the right arm was 146 mm. of mercury and the diastolic pressure was 90; the systolic blood

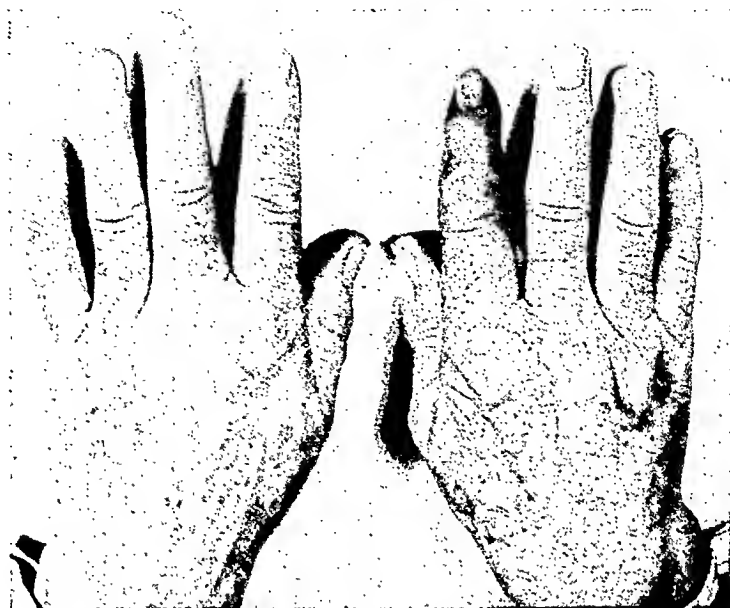


FIG. 7. Dorsal view of hands, showing discoloration and enlargement of right index finger.

**CASE IV.** A man, aged 60 years, complained of pain and swelling of the right index finger of two years' duration. Eight months previous to his admission, the patient had sustained a right Colles' fracture; this had healed without untoward incident.

General physical examination revealed nothing of significance except for the findings relative to the right hand. (Figs. 7 and 8.) The blood pressure, in millimeters of mercury, was 170 systolic and 110 diastolic in the left arm. The right index finger was swollen as a result of the dilated veins. Early gangrene was noted at the tip of the finger. The maximal surface temperature of the right hand was  $2.5^{\circ}$  to  $3^{\circ}\text{C}$ . higher than that of the left hand. A clinical diagnosis of arteriovenous fistula was confirmed by the demonstration of a high admixture of arterial blood in the veins of the right hand. An abnormal communication between the artery and veins could be demonstrated in the arteriograms. Satisfactory recovery followed amputation of the index finger through the metacarpophalangeal joint. Dissection of this finger revealed at least three arteriovenous fistulas between one of the digital arteries and the accompanying vein. On the thirteenth post-operative day the concentration of oxygen in blood removed from the veins of the right and left hands was the same. In forty-nine days

pressure was 155 in the left arm and the diastolic, 94.

Once the single or multiple character of an arteriovenous fistula has been established, the surgeon plans his approach to the lesion and ligates and divides, or excises, the communication. If the vessels are large, an insoluble ligature material, such as silk or linen, is best to use. The surgeon can be most certain of results when the artery and vein above and below the communication are divided and ligated and this is sometimes done when the collateral circulation has been well established or the lesion is of such extent that conservative management is impracticable.

In cases in which congenital arteriovenous fistulas consist of masses of vascular tissue, the excised tumors often are diagnosed as hemangiomas by the pathologist. Arteriovenous fistulas of this nature may respond favorably to injection of sclerosing agents into the blood spaces. However, the dilution factor in cases in which bruit is present may impair results. The extent of the injection should be under control and, following the injection, compression should



be applied, first manually and later by a sponge rubber bandage applied over the area. Treatment is best carried out under multiple injections.



FIG. 8. Arteriogram of right hand illustrated in Figure 7. Beginning gangrene. Arteriogram was made by injecting thorotrast (10 c.c.) into right brachial artery. Three arteriovenous fistulas were demonstrated in the amputated specimen.

#### TALIPOMANUS (CLUBHAND)

Normally the axis of the hand parallels that of the forearm. Disturbance in the relationship of these axes results in the deformity denoted "clubhand." It may be either congenital or acquired. Bony defects may or may not be present in cases of congenital clubhand. Cases in which the condition is contractural in origin and bony defects are absent, are very rare. Congenital clubhand is commonly associated with defects of one of the two bones of the forearm.

Bilateral clubhand is seen about as often as is the unilateral variety. Other congenital malformations frequently are associated with clubhand.

*Clubhand Due to Absence of the Radius.*  
This condition was observed by Tubby in

eleven cases and he surmised that about three cases of this type were seen annually at the Royal Orthopaedic Hospital in London. In 1923, Kato analyzed 253 cases in a review of the literature. Radial defects are far more common than defects on the ulnar side of the forearm. Congenital absence of the radius frequently is associated with absent or rudimentary thumb and carpal bones on the radial side, atrophy of the forearm and an enlarged and curved ulna. Aplasia of the radius may involve the diaphysis only, the proximal end only, the distal end only, or the entire radius may be absent; the last is the most common malformation. The disorientation frequently involves vessels, nerves and muscles. A history of the same condition affecting forebears is noted only occasionally.

Clubhands usually are seen by the physician when the patient is in early life. This permits conservative measures such as massage, manipulation and immobilization to be carried out. Later in life reconstructive procedures may benefit function by correcting the deformity and securing stability.

Contracted muscles, scar tissue and tendons holding the hand in a deformed position can be corrected by plastic procedures. Stability can be secured by bone grafting, the bone being removed from the hypertrophied ulna or elsewhere. In 1928, Albee reported a case in which the result was excellent seven years following implantation of an autogenous graft. Osteotomy or excision of a wedge-shaped piece of bone may be necessary to overcome bowing of the ulna. An important part of the management of these cases is adequate immobilization with proper and persistent after care.

*Clubhand Due to Absence of the Ulna.*  
Clubhand due to congenital absence of any portion of the ulna is found much less frequently than clubhand resulting from absence of part or all of the radius. Kanavel was able to find in the literature reports of only about fifty cases in which the condition was attributable to absence of part of

the ulna. The clinical picture is characterized by a deformed elbow; a short, atrophic forearm; bowing of the radius; ulnar deflec-

badly suppressed developmentally that reconstructive surgical measures are useless.

*Clubhand on a Contractural Basis.* Club-

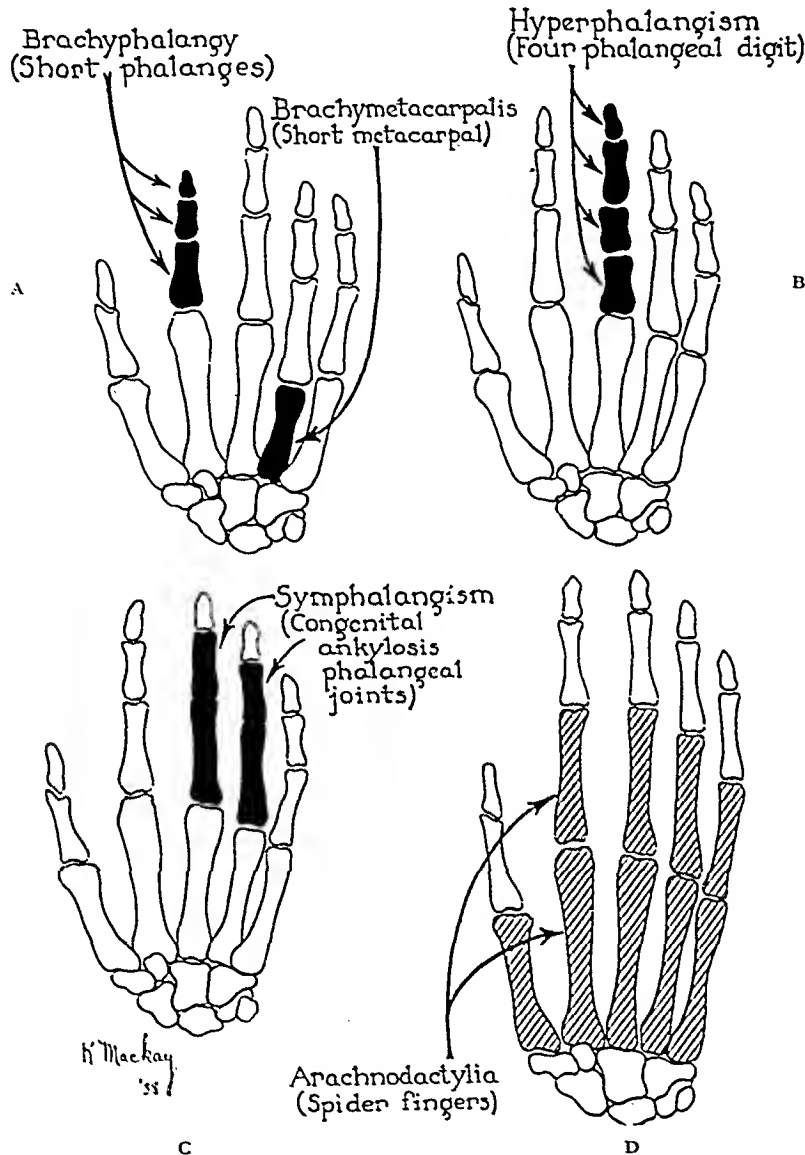


FIG. 9. Various congenital deformities.

tion of the hand and frequent suppression of the third, fourth and fifth fingers. Malformation of the carpal and metacarpal bones on the ulnar side of the hand is a commonly associated condition. The radius frequently is dislocated upward at the elbow. The function of the hand usually is much better than that of the hand which is associated with involvement of the radius.

Function in most instances is so satisfactory that surgical intervention is not indicated. When aplasia is present and is in such degree that bone grafting is required to secure stability, the hand usually is so

hand on a contractural basis is analogous to congenital clubfoot. In the treatment of contracted clubhands, without bony defects, plastic procedures on the fascia and tendons usually are sufficient. These procedures are to be followed by adequate immobilization and proper physiotherapy.

#### MALFORMATIONS WITH EXTENSIVE MALDEVELOPMENT

Absence of segments of the humerus or forearm, with the hand attached to the body; absence of the forearm and hand; absence of the hand alone, and ectro-

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dactylia or absence of fingers (which was discussed earlier) are among the more severe types of congenital impairment of growth. The extent of aplasia varies from absence of the smallest anatomic unit to absence of an entire extremity. Frequently more than one extremity is involved.

## MALFORMATIONS WITH MILD MALDEVELOPMENT

**Congenital Contraction Furrows.** Congenital contraction rings, or so-called amniotic furrows, are deformities of milder degree. These contraction bands consist of dense fibrous tissue and may encircle the extremity at any level. They may be multiple and other congenital malformations may or may not be associated with them. That portion of the extremity which is distal to the contraction ring may exhibit any degree of maldevelopment and may determine the advisability of surgical removal of the contraction furrow.

Mention should be made of fusion of digits, of metacarpal bones and of carpal bones. Fusion of digits such as is seen in syndactylia already has been discussed. Fusion of the phalanges in the same finger will be discussed under symphalangism. Any degree of fusion of the metacarpal bones may be seen, varying from the slightest to the most complete. Partial fusion of the metacarpal bones usually takes place at their proximal ends.

## CONGENITAL VARIATION IN THE CARPAL BONES

Supernumerary carpal bones are not uncommon. Numerous types of the condition have been described. In traumatic cases, frequently it is necessary to distinguish between fracture and a supernumerary bone. A roentgenogram of the opposite hand often will simplify a difficult diagnostic problem. The anomaly may be unilateral but in most cases it is symmetrical.

Many combinations of fused carpal bones have been described. The fusion may be either unilateral or bilateral. It may occur alone or in association with other con-

genital malformations. Fusion of the trapezoid and second metacarpal or of the trapezoid and os magnum may occur. The semilunar and cuneiform or semilunar and scaphoid also may be fused. The trapezium may be fused either with the first metacarpal or with the scaphoid. The semilunar also may be fused both with the unciform and the cuneiform. Complete lack of development of the carpal bones is more frequently encountered on the radial than on the ulnar side and usually is associated with malformation of the radius and thumb.

## SYMPHALANGISM (CONGENITAL FUSION OF THE INTERPHALANGEAL JOINTS)

Symphalangism is an extremely rare hereditary anomaly characterized by fusion of the interphalangeal joints. (Fig. 9c.) Usually it is bilateral and frequently it is associated with other congenital malformations. Genealogic investigations have demonstrated that the anomaly is inherited according to Mendel's law. Drinkwater has traced the condition back fourteen generations. Should the function of the hand be seriously impaired the only applicable surgical procedure would be arthroplasty.

## BRACHYPHALANGIA AND BRACHYDACTYLIA

Throughout the literature these terms are used synonymously to describe an hereditary deformity characterized clinically by shortening of the fingers or toes. (Fig. 9A.) Shortening of a finger, congenital in origin, may be due to complete lack of development of a phalanx (anphalangism), shortening of a phalanx (brachyphalangia) or shortening of a metacarpal bone. Stecher has suggested the term "brachymetacarpalia" to describe the deformity that is due to shortening of a metacarpal bone.

A congenitally short finger is more often associated with a short phalanx than with a short metacarpal bone. Brachyphalangia may affect any of the five digits; shortening of any of the five metacarpal bones may occur. Simple absence of a middle phalanx is most often seen. These malformations

usually are bilateral and are hereditary; surgical operation seldom is employed for their correction. Traction and oblique osteotomy or bone grafting are the only means of lengthening the finger.

#### HYPERPHALANGISM

Hyperphalangism is a very rare congenital malformation, characterized by the presence, in a finger, of four phalanges instead of three or, in the thumb, of three phalanges instead of two. (Fig. 9B.) Considerable controversy has arisen as to the origin of the supernumerary phalanges. Kanavel expressed the belief that supernumerary phalanges have their origin in disorientation of the epiphysis of the proximal phalanx. He offered the explanation that the protuberance seen on the radial side of the epiphysis may continue to grow and may become a separate phalanx. A familial history of the anomaly frequently is elicited. Lossen, in 1937, and Frere, in 1930, reported cases and furnished excellent roentgenographic illustrations.

#### ARACHNODACTYLIA (SPIDER FINGERS)

Arachnodactylia was first described by Marfan in 1896. It is characterized by the striking length of the extremities, especially of the hands and feet. (Fig. 9D.) To this are added other congenital malformations such as cardiac and pulmonary anomalies, ectopia lentis, hypotonicity of the muscles, spurs of the os calcis, and a highly arched palate. A roentgenogram of the hand discloses the presence of slender metacarpal bones and phalanges. The long bones of the extremities, the metacarpal bones and the proximal row of phalanges may be unusually long, while the middle and distal phalanges are of normal length.

#### MULTIPLE EXOSTOSIS

Multiple congenital osteochondromas, hereditary deforming chondrodysplasia (dyschondroplasia), hereditary multiple exostosis and diaphyseal aclasis belong in this group. Multiple exostosis is a hereditary condition characterized by more or less

symmetrical bony or cartilaginous overgrowths occurring at the diaphyseal extremities. The hands may be involved as well as other parts of the skeletal system. Because of the proximity of the abnormal tissue to the epiphysis, disturbances of growth frequently are encountered. The cortex of the diaphysis may have irregular instead of regular margins. Of the bones of the hands, both phalanges and metacarpals may be involved but the carpus and epiphysis escape. (See Fig. 5C.)

#### CLEIDOCRANIAL DYSOSTOSIS

Cleidocranial dysostosis is congenital in origin and is characterized by absence of the clavicles, by cranial malformations and by disorders of dentition. The bones of the hands may be malformed. The distal phalanges are conical and may be shortened. The diaphyses of the proximal row of phalanges and metacarpal bones may be thinned and the cortices may be of increased density. There may be some shortening of the middle row of phalanges and of the metacarpal bones. The proximal row of phalanges may be expanded at their proximal ends. Klemmer, Snoke and Cooper, in 1931, and Pillsbury, in 1927, have reported cases with good illustrations and have described the roentgenologic appearance.

#### HEREDITARY DYSTROPHY OF THE NAILS

Various types of congenital malformation of the nails have been reported. The condition may or may not be associated with congenital malformations elsewhere in the body. Turner, in 1933, reported two families of which some members had dystrophy of the nails, associated with congenital anomalies of the joints; the condition affected thirty-five of seventy-nine persons. Sever, in 1938, reported a case in which the involvement was similar.

#### SUMMARY

It is obvious from the foregoing report that the multiplicity of congenital lesions presents problems in treatment which require accurate knowledge concerning

which of the bones and soft tissues are involved. By means of surgical treatment and postoperative physical therapy many of these deformities can be remedied, with benefit both in appearance and function.

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# THE MANAGEMENT OF POSTURAL DEFORMITIES OF THE LOWER EXTREMITIES

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WHEN any part of the lower extremity assumes abnormal posture, the rest of the leg is also affected.

For example, the lordotic lumbar spine and acutely tilted pelvis, by shifting forward the center of gravity, cause the femora to rotate internally; the knees may slacken (slightly flex) and increase their abducted position because the inwardly rotated leg has brought the weight-bearing line closer to the median sagittal plane. In this position ligaments are put on strain, and a greater amount of muscular energy is used to maintain the erect posture. Conversely, the flattened lumbar spine and more horizontal pelvis shift the center of gravity back and cause the legs to rotate externally. The second metatarsal then comes under the weight-bearing line, so that the body approaches a point of balance which can be maintained with minimum effort.

The part of the lower extremity showing the greatest deviation from normal is the foot. It is here that abnormalities are most important, because the foot is not only the base or pedestal upon which the superstructure is balanced; it is also a dynamic propulsive organ. Sir Arthur Keith<sup>17</sup> puts it in these words: "The foot is a postural structure; it cannot undergo any change of an advantageous kind unless every other structure in the body which is concerned in the maintenance of posture undergoes a harmonious alteration at the same time."

Since the foot plays such a vital part in leg posture, it is necessary to study its problems in detail. A brief anatomic survey is therefore desirable.

## ANATOMY

The foot may be divided conveniently into three units: posterior (astragalus and

os calcis); middle (five small tarsal bones which form a wedge, base medial); anterior (metatarsals and phalanges). The articulated foot forms a tripod of longitudinal springs (arches) upon which the leg is balanced. It is tied together by heavy ligaments and powerful muscles.

The conformation of the ankle, though a pure hinge-joint, provides against the slipping forward of the leg bones on the astragalus by the broadening of its body anteriorly.<sup>14</sup> This locks the two malleoli against the astragalus as they tend to slip forward because of body weight plus the active forward dislocating action of the long plantar muscles winding around behind their malleolar pulleys.

The frontal plane of the ankle joints is not at right angles to the sagittal plane, but oblique, and together the two ankles form an angle of 169 degrees open backward. Because of this obliquity the ankle joints tend in standing to bind on forward motion of the tibiae, and this propensity becomes an aid in keeping the upright position (Dane<sup>10</sup>).

The lateral ligaments of the ankle joint run down and backward from the malleoli to assist in counteracting the forward thrust of the leg on the astragalus. The superficial or calcaneotibial portion of the deltoid ligament passes from the malleolar tip to the sustentaculum tali, and so restrains the os calcis from too great eversion. The deep or fan-shaped deltoid part spreads out to attach to the whole medial surface of the astragalus and to blend with the spring ligament (calcaneoscaphoid) to form a suspensory mechanism for it.

In the astragalocalcanean or "sub" ankle joint is the key to most foot disorders. The astragalus rests in a cradle extending in an oblique sagittal plane



formed by the three facets of the calcaneus, the spring ligament, and scaphoid. These articulating surfaces are concave except for the posterior convex, saddle-shaped facet on the calcaneus. "The talus (astragalus) can slide like a bolt on its long axis which runs downward, forward, and medially."<sup>14</sup> It also allows for inversion and eversion of the os calcis, which rotates under it.

The transverse or mid-tarsal articulation (astragalo-scaphoid and calcaneo-cuboid) is complementary to the astragalo-calcaneal. Therefore, these are joints of inversion and eversion. From the cuboid, a process projects backward (the calcanean angle) at its lower and medial border under the calcaneus.<sup>14</sup> It transmits the upward thrust of the peroneus longus to the calcaneus. Considerable variation in this joint up to the purely vertical is noted by Dane.<sup>9</sup>

The course and insertion of the long plantar muscles, the posterior tibial, flexor hallucis longus, and peroneal longus, require particular mention: As the posterior tibial tendon curves under its pulley, the medial malleolus, it can exert a strong forward and lifting action, approximating the medial malleolus to the scaphoid tuberosity. It runs forward under and superficially to the spring ligament, giving it support, and inserts two-thirds into the tuberosity of the scaphoid and one-third into finger-like bands diverging to the remainder of the tarsus (except the internal cuneiform), and to the second, third, and fourth metatarsal bases. The flexor hallucis longus is the only tendon running directly under the sustentaculum; it gives a strong upward and outward thrust on this pulley. The peroneus longus uses the external malleolus as a pulley to wind forward under the cuboid, and takes its way diagonally under the sole of the foot to the base of the first metatarsal and first cuneiform.

The abductor hallucis is an important *short* plantar muscle because although it has lost its active abduction power, it depresses the head of the first metatarsal and acts as a spring tie-rod along the inner border of the foot.

#### DYNAMICS OF THE FOOT

In recent decades more attention has been paid to the dynamics of the foot than to its static architectural arch structure. The tendency is to avoid the idea of the arch with its keystone. Some writers deny their existence, and regard the hollowed sole of the foot as made up of flexible trusses or springs.

Speaking of the foot, Sir Arthur Keith<sup>17</sup> says, "Attention must first be directed to its prime movers, its muscles—Nature never uses ligaments as prime supporters in the structure of the animal body . . . ligaments serve only as safeguards." Steindler<sup>25</sup> agrees that "in the maintenance of the normal configuration of the foot the muscles stand in the first line of defense."

Dudley Morton,<sup>21</sup> Lake,<sup>19</sup> and Wiles,<sup>27</sup> however, believe that the muscles merely assist in maintaining balance, and that weight is distributed throughout the foot from bone to bone much as it is transmitted from femur to tibia. Wiles concedes that the intrinsic muscles may play a part as tie-rods to the long arch. He emphasizes the independent up-and-down action of the hallux unit, which includes the inner cuneiform, and assigns to the abductor hallucis and the peroneus longus the function of depressing this metatarsal head. There is no doubt that this motion was well-developed in the grasping function of the hallux unit in the arboreal stages of foot evolution.

Nevertheless, it is clear that muscle pull can profoundly change the balance of the foot. This can well be seen in the deformities resulting from muscle imbalance in anterior poliomyelitis.

The three long plantar muscles play the major rôle in maintaining foot equilibrium. Just as the posterior tibial is the strongest, most persistent offender in producing varus deformity in anterior poliomyelitis, so it is the chief defender against eversion of the foot in walking or standing. The peroneus longus is generally considered the second most important muscle in its sling-like supportive action, as it passes under the

tarsus, tying it together, and secondarily stabilizing the hallux. In this latter capacity it is really a synergist to the tibialis



FIG. 1. Foot of seven months fetus, before the fatty instep pad found at birth has developed. A well-marked arch is already present. (From Lake's "The Foot," William Wood.)

posticus. By some authors, the flexor hallucis longus is given first place because it is a large, bulky muscle and because it acts directly on the os calcis through the sustentaculum.

#### BONY ABNORMALITIES OF THE FOOT INFLUENCING POSTURE

That hypermobility and shortness of the first metatarsal may influence foot balance and have to be compensated for, is shown by Morton.<sup>21</sup> Variation in ossification and accessory or inconstant bones may also be of importance in production of the everted foot and may present a bony resistance to correction. Pfitzner states that synostosis of constant tarsal elements takes place through the medium of an inconstant one. Dane<sup>9</sup> in a careful study of 177 specimens found an articulation between scaphoid and cuboid in 43 per cent; astragalar-cuboid 5 per cent (which must have an effect on foot mechanics); and calcaneo-scaphoid articulation in 28 per cent, with fibrous ankylosis in one and a bony bridge  $\frac{3}{8}$  inch thick in two. This was described in later years by Slomann as *coalitio calcaneo-navicularis*. Complete union is by fusion of the inconstant bone (*os calcaneus secun-*

darius) to its two tarsal neighbors. This fixes the foot in an everted position.

Kidner<sup>18</sup> has emphasized the abnormal attachment of the posterior tibial tendon in cases with an accessory scaphoid. Its attachment is more inward and upward on the scaphoid, and may occur even without the presence of the inconstant extra bone. Such an attachment lessens its supinating power.

#### POSTURAL DEFORMITIES OF THE FOOT

The term "flat" foot has been loosely used for pronated, weak, or splay foot. In discussing this syndrome of faulty weight-bearing, Jones and Lovett<sup>16</sup> prefer to use the more definitive word "strain." The true flat foot, that is, absence of concavity of the inner border of the foot, is infrequent except in certain Negro types, and is not ordinarily subject to strain. The usual apparent obliteration of this concavity is due to eversion. In disturbed postural balance the concave inner border is restored in the flexible foot as soon as it is brought under the leg to its normal position in balanced weight-bearing. Even the infant's foot is not flat, as shown by Dane, Lake, and others. (Fig. 1.) The inner longitudinal curve of the foot is, except in thin babies, masked by a pad of fat which, according to Dane,<sup>11</sup> protects the architecture of the foot until it becomes strong enough to dispense with this support.

The superincumbent body weight reaches the foot through tibia and astragalus and is distributed to fore and hind foot in a ratio of three to five. The medial eccentric position of the astragalus in the tarsus and the pronating and supinating movement in the "sub" ankle joint (subastragalar and mid-tarsal) allow this weight to be thrown easily to the inner side of the foot unless the latter is kept in balance by its muscular stabilizers, the long plantar muscles. This elastic inner side of the foot, which has sacrificed stability for the mobility productive of an effortless, springy gait, is the area most vulnerable to abnormal strains.

In young children the pronated foot causes no symptoms beyond a slight awkwardness of gait. If medical advice is sought, it is only because of an apparent enlargement of the inner aspect of the ankle. In the adult, symptoms of foot strain appear after decompensation of muscle control because of: increased weight; weakened muscles following illness; overuse (change of occupation) with feet in a position of imbalance; or continued use of faulty shoes. As one author aptly says, "The foot is the first structure to express by pain the generally relaxed fatigued condition."

Symptoms may come on with dramatic suddenness in a foot that, just struggling along, is forced to take on new and heavier burdens such as standing all day or nursing duty. Much time and suffering can be saved by careful inspection of newcomers to such kinds of work. Osgood<sup>23</sup> found it of definite value to measure by spring balance the relative strengths of supinator and pronator muscles. Normally the ratio is five to four in favor of the supinators. Incoming student nurses were so tested, and exercises, heel wedges, and so forth were given prophylactically to those who fell below normal. As a result, the incidence of foot strain dropped noticeably in classes so supervised.

Symptoms range from slight tenderness over the ligamentous attachments and a dull ache or tired feeling, to acute pain in the entire foot with swelling and extreme tenderness. Freiberg<sup>12</sup> used the tenderness demonstrable over the sustentaculum as the first sign of incipient foot strain, even before subjective symptoms were noticeable. A slip of the deltoid ligament which attaches to it is the first part to feel the effect of strain from an everted foot. In long-standing cases of abnormal weight-bearing, heavy calluses appear on the plantar surface of the foot in areas subject to increased pressure, especially under the inner aspect of the heel or great-toe joint.

**Diagnosis.** It may be thought that static error can be detected at a glance, but

this is only partly true. The everted heel with its abducted forefoot can be seen, but most organic disturbances of the foot also have some complicating static deviation which is visible. The difficulty lies in identifying the organic condition underlying the apparently simple postural defect. Lack of attention to the possibility of organic disease naturally leads to disappointment in treatment.

Peripheral vascular disease is to be suspected in cold, cyanotic feet, particularly if accompanied by a history of cramping in calf muscles. Blanching of the soles when raised above heart level is a strong indication of its presence.

The subacute or chronic case of gout has more than once been "treated" by arch supports, but the intermittent character of the symptoms, x-ray changes, and finally uric acid determination, should identify this not-so-infrequent disturbance beyond the possibility of such error.

In their incipient stages, central nervous system diseases that lead to foot abnormalities may also cause confusion. Tests for reflexes, including the plantar response, should always be made.

Mild arthritis too may be overlooked unless attention is paid to history, other joints, and x-ray examination. Moreover, disturbances of alignment of the lower extremity, coxa vara, genu valgum, and inequality of leg length must be taken into account.

**Treatment.** Fundamentally, the aim of treatment is to restore correct weight-bearing alignment of the foot with the leg to assure transmission of weight both in standing and in motion so that the tripod-like weight distribution in the foot receives its proper proportion at each of the three main supporting points.

For young children, who are usually symptom-free, Whitman<sup>26</sup> is insistent on corrective treatment. He says, "It is in childhood that the prevention of subsequent weakness and deformity is of the first importance." To the child too young to coöperate in corrective exercises, his

rocker-type arch support is of distinct value. It is different with those adults, particu-

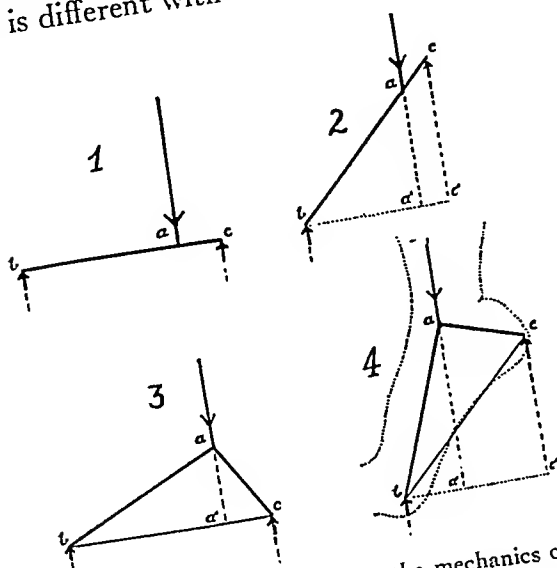


FIG. 2. Diagrams to illustrate the mechanics of the high heel. If the foot were a simple lever (1) its elevation would produce no change in the proportion of the weight falling on b and c, for (2) ba and ba' diminish in the same degree as ac and a'c'. The actual arrangement is, however, seen in (3), where the relative lengths were obtained from roentgenograms. The axis of rotation is at a some 2 inches above the sole, and when the heel is raised the result is seen in (4), where ba' is tremendously diminished while a'c' is increased, so that a much greater proportion of the weight is now carried at b. (From Lake's "The Foot," William Wood.)

larly elderly folk, whose poorly balanced feet may be painless and have become adjusted to the changed forces of weight-bearing. In such cases it is wise to curb one's enthusiasm for postural correction, which may only precipitate trouble. Slight symptoms in such patients are best alleviated by a mild supportive foot plate or pads.

In the extreme, acute case, bed rest is indicated, followed by inversion strapping or even plaster boot. When symptoms have subsided, the patient may be handled as is the ordinary protracted case, described below.

The chronic patient intelligent enough to be coöperative and old enough to understand (this includes some children as young as 6 or even 4) should bend every effort

toward correction by exercise. Arch supports should be avoided whenever possible, but if used, should be looked upon as crutches only. The patient must be impressed with their weakening effect on the foot musculature. All too often a vicious circle is set up: the patient obtains relief from pain by use of a support; he relies on it exclusively, makes no effort to restore muscle tone; and as the result of the increasing weakness in foot musculature, he becomes more and more dependent on the artificial aid. As the years go on, it has to be made more supportive, until wearing it becomes a burden, and all semblance to ordinary elastic gait disappears.

As a matter of fact, carefully selected shoes may provide the only needed artificial support.

The medical profession has long been aware of the influence of foot-gear on foot mechanics. M. Andry in his *Treatise Orthopaedia*,<sup>13</sup> 1742, wrote, "Shoes that are too high-heeled will make the bodies of children crooked." Peter Camper's *Disquisition on Best Form of Shoes*, 1791, influenced thought on footwear for generations, and T. S. Ellis in 1889 said, "Let the form of the boot lasts correspond in shape to that of the feet in action."<sup>2</sup>

This ideal has been arrived at to a degree in the present type of semi-orthopedic shoe, which by merely eliminating the pointed end gives adequate toe-room, and is at the same time pleasing in appearance. The full orthopedic shoe with its exaggerated in-swing of the sole does little more than produce corns and other pressure manifestations. One author thinks they would be helpful only to the palm-climbing native who uses his feet in an over-supinated position! In short, they are ugly, unnecessary, and not tolerated by the intelligent patient except under duress.

In the proper shoe, a straight inner border is desirable. The heel should be snug (combination width lasts provide the means) and the waist of the shoe should clasp the instep firmly. There should be ample toe-room. The semi-orthopedic shoe

generally has a semi-rigid shank, which is advantageous because it will not lose shape easily, thereby prolonging the corrective effect of heel wedges and so forth. One of the objections which often arise in otherwise satisfactory shoes is that the heel-to-ball length is shorter than that of the foot, so that the arch of the shoe in its forward part falls short of that of the foot. This has the effect, if the upper is snug, of strapping the foot firmly to a board and greatly limiting any up-and-down play of the independent first metatarsal unit. Shoe manufacturers manage to accomplish this result in another way also, by flattening the vamp part of the upper in order to eliminate wrinkles. This again ties down the first metatarsal.

Little need be said about the woman's high-heeled shoe. A brief study of the diagrams reproduced from Lake's book, *The Foot*, is convincing. (Fig. 2). Even the  $2\frac{1}{2}$  inch heel causes the metatarsals to meet the ground at an angle of over 50 degrees. An average foot in good postural tone, however, can tolerate them for three or four hours without discomfort. Young women may insist that they suffer no ill effects from continually wearing them, but the throngs of older women besieging orthopedic clinics and supporting appliance makers belie their statement.

Alteration of shoe balance was described to us by H. O. Thomas, who described his crooked heel in 1874. Originally this wedge was carried forward to end just behind the first metatarsal head, giving the foot a correction similar to that attributed to the Whitman foot plate. The present-day Thomas or extension heel, however, is carried forward only  $\frac{1}{2}$  or  $\frac{3}{4}$  inch under the inner border of the arch. It should come forward to the plane of the tuberosity of the scaphoid, which is rarely less than  $\frac{3}{4}$  and often 1 inch. The wedging of the inner border of the heel may be  $\frac{3}{16}$  to  $\frac{1}{4}$  inch. Usually it is effective in correcting the heel eversion if the heel of the shoe fits snugly and has a firm counter. J. J. Nutt<sup>22</sup> has further modified the

original Thomas heel by using a short anterior heel just behind the first metatarsal head. It is built to balance the sole,

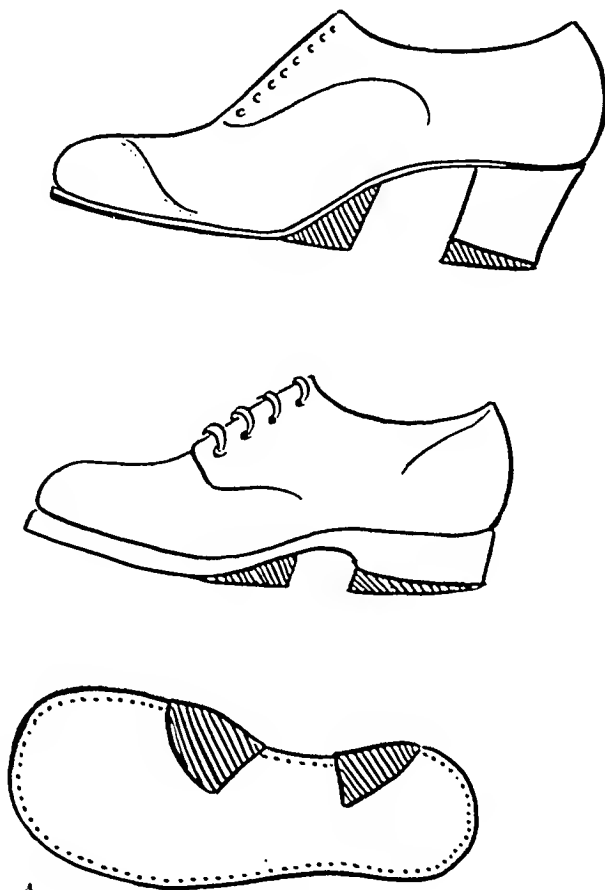


FIG. 3. Anterior heel. (From Nutt, in *Am. J. Surg.*, 32: 53, 1936.)

level with the regular heel, which has had its forward inner corner raised  $\frac{1}{8}$  to  $\frac{1}{4}$  inch for correction of heel eversion. (Fig. 3.) This anterior heel effectively checks abduction of the forefoot and yet permits some flexibility to remain in the shoe. (Rigid metal arch supports do not.)

If actual support under the scaphoid is needed for a time completely to relieve symptoms, the rubber oval scaphoid pad may be cemented into the shoe. If placed far enough back toward the heel, it does not interfere with the action of the first hallux unit, and in addition to its supporting and supinator action, it effectively limits forward slipping of the very flexible foot.

For localized pressure points under metatarsal heads, the conventional meta-

tarsal pad cemented into the shoe suffices. Even better is the leather metatarsal bar placed on the sole just behind the meta-

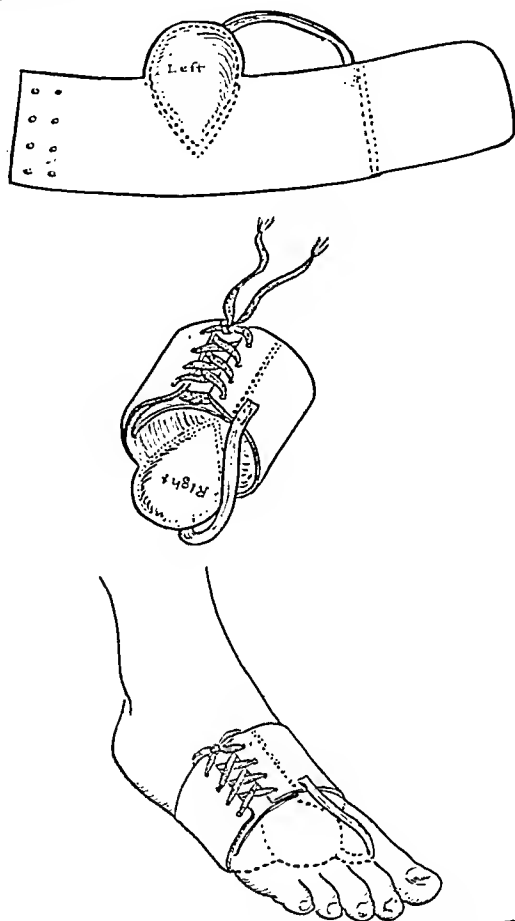


FIG. 4. Leather metatarsal cuff.

tarsal heads. If the forefoot is of the very flexible accordion type, it is better to incorporate the metatarsal rubber pad (felt pads mat down) in a leather metatarsal cuff, which keeps the forefoot from unduly splaying out. (Fig. 4.)

Exercise, the most important step in conservative treatment of postural deformities of the foot, is, ironically, the most difficult, because it is not easy to get and keep the patient's cooperation. Handing him a printed explanation of exercises is wasting paper; he must be not only convinced of their value but also made enthusiastic about persevering at them.

The chief disadvantage of exercises and exercising devices is that a certain hour

must be set aside for them, usually in the evening. There is much doubt in my mind that ten minutes of even conscientious exercise at the end of a fatiguing day can counteract the breaking down effect of eight hours or more of pounding hard, unyielding city pavements or floors. Therefore, I depend upon one exercise which can be done in the shoes six or eight times daily, never for more than sixty seconds at a time, and at odd moments such as while shaving, brushing the teeth, or standing in subways. Its main value is that it can be repeated frequently and without loss of time. One merely has to think of it to do it. The exercise consists of standing in a slightly forward-leaning position to increase the weight on the forefoot. The toes are firmly plantar-flexed, pushing up the mid-foot like a cat's arched back, and rolling the foot slightly to its outer border. All this must be done with real effort, as if actually lifting the body weight. The tendency for the head of the first metatarsal to leave the ground must be firmly resisted. This exertion calls into action the peroneus longus. The contraction of the toes employs the long and short toe-flexors, and the moderate inversion motion makes the tibialis posticus work. Contracting the glutei maximii (pulling the cheeks of the buttocks together) while thus curling the toes tends to correct the internal rotation of the leg which accompanies foot pronation, and it helps to bring the leg and foot into equilibrium more quickly. The value of this exercise (gluteal contraction) was emphasized by Lowman in 1912, has been reiterated from time to time by subsequent authors, and has been periodically forgotten by the majority.

If heel cords are short, that is, if they do not permit dorsiflexion of the supinated foot to a right angle, they should and can be stretched. This can be done manually or by the following method. The patient faces the wall an arm's length away, standing on the outside of his feet without shoes, toes curled under, heels on the floor. Keeping the body stiff, he lets it fall toward the

wall by bending the elbows. The feet must be kept supinated in order to avoid straining the inner borders. (Fig. 5.) If this performance is properly done, real strain is felt behind the knees and in the calves. Some authors deny that the tendo Achillis can be stretched. Thoroughness and perseverance in the fashion here recommended will prove them wrong. The rare case, so severe and persistent that stretching will not cure it, can be so much helped by lengthening that operative correction is worthwhile.

The Shaffer shoe and its modifications are positive mechanical means of stretching heel cords.

To obviate aching in the calf, an active symptom of short tendo Achillis, some men advocate raising the heel. To my mind this is robbing Peter to pay Paul, because although it may relieve the symptoms, it throws extra weight on the metatarsal heads and hastens the day when they will sing out with pain.

One other common exercise is to be mentioned only to be condemned: rising up on the toes, tilting to the outer border of the feet, and lowering the heels to the ground. The upward and downward motion of the heels is done by the calf group, usually already shortened and hypertrophied. The outward rolling calls only the peronei into action to combat the tendency of the feet to collapse laterally to an advanced degree because of the oblique set of metatarsal heads. The tibials and toe flexors may be completely passive.

For the older patient who cannot benefit by exercise, and for the uncoöperative patient who will not, artificial aids may be employed. Metal arch supports are better avoided unless the deviation is extreme or overweight is marked. Wedged heels and rubber scaphoid pads usually suffice. The single outside bar brace with inside  $\pi$  strap can be used to advantage in the very flaccid foot to hold correction until training can restore the muscles to somewhere near the normal. It is of particular value in the convalescent treatment of peroneal spasm.

Almost as efficient corrective support can be obtained temporarily by an inversion adhesive strapping. It is not enough, how-



FIG. 5. Exercise for stretching of tendo Achillis.

ever, to strap the hind foot in inversion because then the long lever of the forefoot is not controlled and forces the heel back to its original position, stretching the adhesive. The forefoot should be held in adduction, and overlapping diagonal strips of the tape should be carried from just behind the head of the fifth metatarsal up on to the inner aspect of the leg, there to be incorporated into the posterior stirrup strapping. (Fig. 6.)

In the more extreme degrees of flexible pronated foot, it may be necessary to resort to operative correction if any semblance of foot balance is to be achieved. Of the many operations



tried and advocated, three deserve particular consideration:  
Scaphocuneiform fusion with remodel-

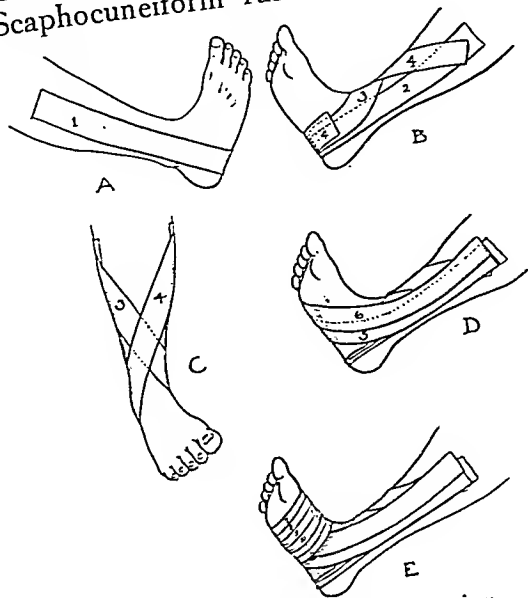


FIG. 6. Inversion foot strapping.

ling of the inner border of the foot was described by Hoke<sup>15</sup> in 1931. It has given excellent results in his and others' hands. Hoke's own cases were presented after a five- and six-year follow-up. Attention must be paid to proper moulding of the foot with adequate plantar flexion of the first metatarsal head.

For anomalous attachments of the tibialis posticus usually associated with an accessory scaphoid, Kidner,<sup>18</sup> in 1933, reported a transplantation. The posterior tibial tendon was returned to its normal site in a groove under the scaphoid. When done in the properly chosen foot and followed up by an adequate muscle training, this operation gives very satisfactory results.

Oscar Miller,<sup>20</sup> in 1927, gave an account of advancement of the calcaneoscaphoid (spring) ligament by means of an osteoperiosteal flap. This changes the contour of the inner border of the foot, but does not cause ankylosis of any of the tarsal joints.

#### POSTURAL DEFORMITIES OF THE LEG

Practically all deformities of the leg are caused by organic changes in its bone or

soft tissue structure. However, Kuhns attributes the very common knock-knee deformity seen in adolescents, particularly girls, to poor posture resulting from a general muscular imbalance. The prominent lax abdomen allows forward inclination of the pelvis with relaxation of the glutei and consequent inward rotation of the femora. This produces an apparent and later real external rotation of the tibiae. Such a stance habitus if long continued, influences the growing long bones until an organic knock-knee gradually ensues. In examining a thousand girls from 8 to 18 years of age, Kuhns found knock-knee on such a basis in 20 per cent. He measured the distance between the malleoli with the patient supine, legs straight, and knees touching. One inch separation or less was considered normal, between 2 and 3 inches moderate, and 4 inches or more severe.

As regards treatment, Kuhns feels that practically all mild and moderate knock-knees can be corrected with wedges (up to  $\frac{1}{4}$  inch) on the inner border of the shoes, supplemented with exercises to improve the strength of the inner hamstrings. Knee flexion and extension exercises help if a pillow is inserted between the knees and the feet are tied together. Cyriax<sup>8</sup> also stresses muscle re-education in those who show muscle imbalance.

This malalignment of the knee, being confined primarily to a definite age group, is of slight importance compared with the postural deformity of the foot, which, occurring continually throughout all age groups and frequently to a severe degree, is much more serious. It is for this reason that the latter must form the basis of any discussion of postural deformity of the lower extremity.

#### SUMMARY

That postural deformity in the foot influences general body mechanics has been emphasized here. That defective body posture also affects foot mechanics must also be remembered.

The discussion of anatomy and function of the foot supports belief in the fundamental importance of an adequate muscle tone and balance.

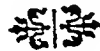
Under diagnosis, the possibility of confusion of postural difficulties with organic disturbances is mentioned.

The several methods of conservative treatment are touched upon, and the matter of exercise is elaborated.

Restoration of muscle tone and of postural balance is considered fundamental.

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# STABILIZATION OF THE HIP JOINT

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**S**TABILIZATION of an unstable hip joint is probably more essential to efficient ambulation than analogous measures in any other joint in the body. In the absence of gross deformity, function can be restored to the flail knee and ankle by means of properly constructed apparatus. The mechanics of the hip in weight bearing are such that efficient apparatus cannot be adjusted to compensate adequately for instability. Consequently partial or complete restoration of function can be accomplished only by reconstructive surgery.

In surgical stabilization, as in all surgery of the hip, due consideration must be given the mechanical and physiologic principles involved. These may be briefly enumerated as follows: (1) anatomy and mechanics; (2) embryology and evolution; (3) osseous structure; and (4) circulation.

*Anatomy and Mechanics.* In weight bearing the normal relation between the femur and pelvis is maintained by osseous, ligamentous and muscular supports. When any of these supporting structures are impaired, the pelvis cannot be fixed and instability results. This status is elicited by the classical Trendelenburg sign.

*Embryology and Evolution.* The femur and innominate bone are differentiated from the primitive skeletal anlage at the 0.5 cm. stage, about the fourth or fifth week of gestation. The acetabulum is formed by the simultaneous development of three separate bones. Failure of these three bones to develop synchronously results in a defective support for the femur in weight bearing. Epiphyseal defects are well illustrated by congenital dislocation of the hip and allied conditions.

In the early embryo there is no femoral neck, the head being supported on the

upper extremity of the femoral shaft. At birth the neck is indicated by an angle of about 150 to 160 degrees. As growth increases, this angle decreases, so that when adult age is reached the normal angle between the femoral shaft and neck varies from 125 to 130 degrees. After middle age the angle further decreases as a result of structural changes of advancing age.

*Osseous Structure.* Normally the weight of the trunk is transmitted from the pelvis to the femoral neck on an oblique axis. The stress and pressure of weight bearing and growth are responsible for the development of several systems of bony trabeculae in the femoral neck. The arrangement of these trabeculae, and indeed, the conformity of the entire femur, are ideally suited for the transmission of weight from the pelvis to the knee joint. Physiologic decalcification of this osseous structure may be produced by the inactivity of old age, or by prolonged immobilization.

*Circulation.* The principal blood supply to the head and neck of the femur is derived from the capsular branch of the lateral circumflex artery and from the ligamentum teres. When anatomic reconstruction of the hip joint is desired, the preservation of the capsular artery is of paramount importance; however, surgical stabilization of the hip joint is often necessary after severance of these vessels.

*Etiology.* The causes of instability of the hip joint for which operative measures are required may be enumerated as follows: (1) ununited fractures of the neck of the femur; (2) dissolution of the head and neck of the femur as a result of pathologic processes; (3) congenital dislocation of the hip joint; (4) traumatic dislocation of the hip joint; (5) paralytic dislocation of the hip joint; and (6) Charcot joint.

While all of these conditions are characterized by an imbalance between the femur and pelvis, the choice of operative proce-

In the Watson-Jones approach, the skin incision begins 1 inch below and anterior to the anterior superior spine and passes



FIG. 1. Age 46, eighteen years following bone graft for non-union of thirty months' duration.

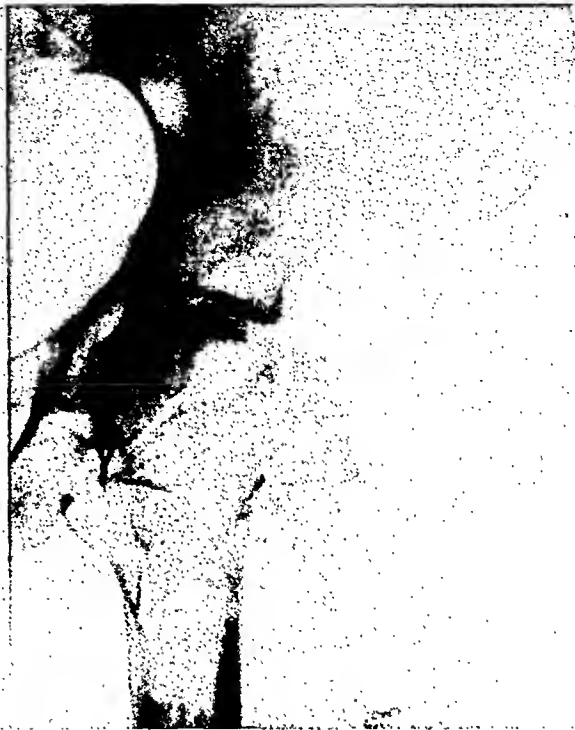


FIG. 2. Age 49 years. Whitman reconstruction operation. Excellent function.

dures varies with several factors. The status of the femoral head and neck, the integrity of the soft tissues acting on the joint, and the age and general condition of the patient must be carefully considered.

*Surgical Approach.* In all operations upon the hip joint the anterior iliofemoral approach, popularized by Smith-Petersen, is the approach of choice. When both the trochanter and hip joint must be exposed, the approach described by Dupuy de Frenelle, or the incision recently popularized by Watson-Jones, is employed by the author.

The technique described by Dupuy de Frenelle is as follows: The skin incision is u-shaped, passing along the iliac crest as far as the anterior superior spine, then curves backward below the greater trochanter. The tensor fasciae femoris is severed at its origin and the sartorius retracted. The gluteal muscles are stripped from their insertion, exposing the hip joint.

directly to the trochanter, where it turns down along the lateral surface of the thigh. Dissection is carried out through the interval between the tensor fasciae and the gluteus medius. The entire trochanter may be exposed by carrying the dissection laterally.

#### UNUNITED FRACTURES OF THE NECK OF THE FEMUR

Stabilization of the hip joint is by far more frequently indicated in ununited intracapsular (or central) fractures of the femoral neck than in any other condition.

When weight is borne on an ununited fracture of the femoral neck, the trochanter is forced up into the gluteal muscles, making fixation of the pelvis impossible. The upward excursion of the trochanter induces marked fibrosis. Pain is usually the outstanding symptom, endurance is always poor, and in most instances, crutches are necessary for walking.

The status of non-union of the femoral neck is reached much earlier than in any other fracture in the body unless efficient

joint. The head usually remains intact because of deficient circulation. The neck has a free circulation, which is essential to



FIG. 3. Age 57 years. Combined Brackett reconstruction and shelf operation. Excellent functional result.



FIG. 4. Age 54 years. Albee reconstruction operation. The femoral head was used as a free graft beneath the trochanter which was transferred to a lower level.

treatment is employed at the time of fracture. A delay of four weeks without reduction may usually be regarded as an ununited fracture, and at the end of two months the definite status of non-union exists. Undoubtedly union may rarely be secured by conservative measures even after the elapse of a longer period of time. This has been demonstrated by Zadek, and recently by A. Meyer. However, the successful results obtained by these two men must be considered as exceptions to the general rule.

In the treatment of non-union of the neck of the femur, conservative measures must be reserved for cases in which surgery is refused or contraindicated. In the opinion of the author, radical measures are definitely indicated after the elapse of four weeks.

After the lapse of time there is a gradual evolutionary change in all the tissues of the

decalcification, and gradually becomes absorbed. After one or two years, only the trochanter and a small portion, if any, of the neck may remain. In time, as the head becomes revascularized, decalcification occurs and in some instances the head disappears.

The strong abductor muscles become contracted and the trochanter is lifted to a higher level, decreasing the length of the limb and further separating the fragments. The posterior ligaments also become contracted, especially the ischiofemoral ligament, maintaining the limb in external rotation and further separating the fragments.

*Operative Procedures.* The first operative procedure devised for this condition consisted of excision of the head and placing the upper extremity of the neck into the acetabulum. This proved a failure as there was usually dislocation with recur-

rence of the original instability. This procedure was the precursor of the reconstruction operations described below.

union decrease with the lapse of time and the degree of absorption. Bone graft is contraindicated in the aged, as less shock-

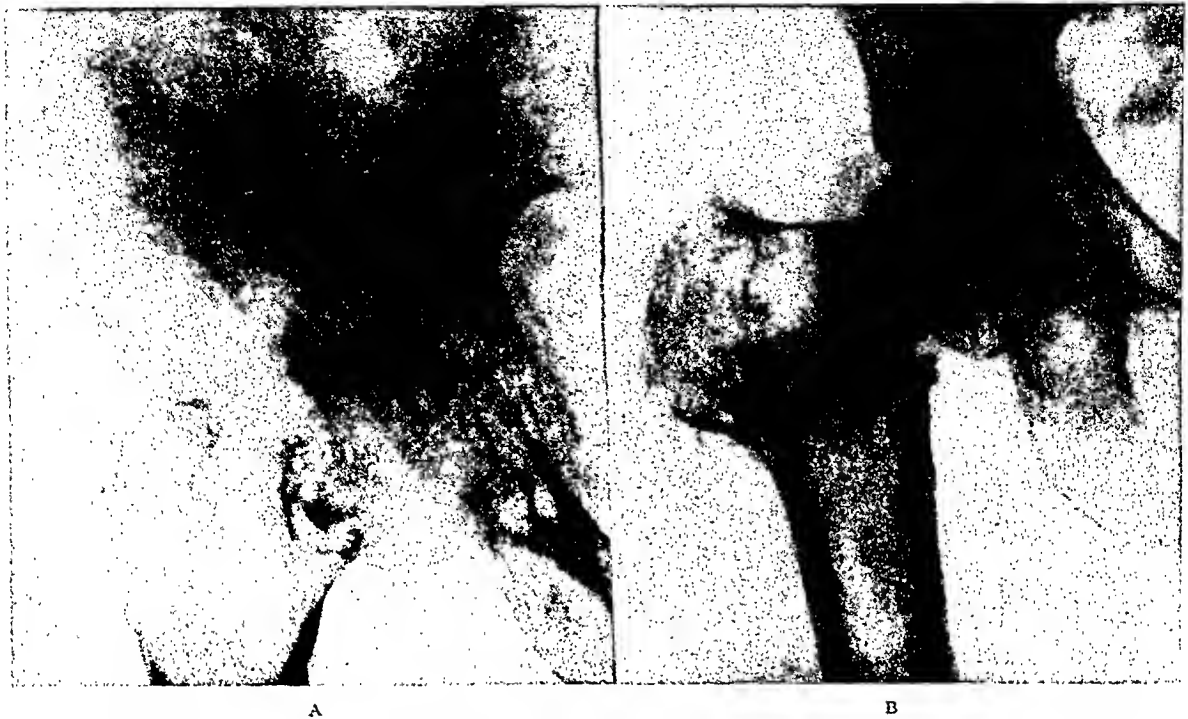


FIG. 5. Age 66 years. A, non-union of ten months' duration. B, solid union and excellent function following osteotomy.

Many operative procedures have been devised for non-union in this location, and no one procedure is applicable to all cases. The indications depend entirely on the status of the individual case. Procedures employed at the present time are as follows: (1) bone graft or pegging; (2) internal fixation by metal nails, pins and screws; (3) reconstruction operation of (a) Whitman, (b) Brackett, (c) Albee, (d) L'Episcopo, (e) Colonna, and (f) the author; (4) osteotomies, intertrochanteric and subtrochanteric; and (5) arthrodesis or fusion.

*Bone Graft of the Neck of the Femur.* When a long proximal fragment and little or no absorption of the neck exists, this procedure offers the possibility of anatomic restoration of the upper extremity of the femur. The operation is particularly advantageous in fairly young individuals with non-union of a few months' duration. Absorption of the neck is not an absolute contraindication, but the chances of solid

ing procedures offer excellent function without the necessity for prolonged fixation (six to twelve months).

The operation is best carried out through the approach described by Dupuy de Frenelle, exposing both the trochanter and the fracture site. The fragments are denuded of fibrous tissue and reduced. An autogenous graft from the tibia or a portion of the entire shaft of the fibula is driven through the center of the neck and into the head. By this means, the denuded fragments may be very closely approximated.

In older patients the graft may be inserted by the method of blind pegging, as is now carried out with various pins, nails and screws in fresh fractures.

Prior to the comparatively recent development of the roentgenographic technique for taking two views of the femoral neck, this pegging procedure had to be carried out with the anteroposterior view alone. The percentage of cases in which both fragments were engaged by the graft with

only the anteroposterior x-ray control is surprisingly large. Experienced surgeons have reported from 65 to 75 per cent solid

Whitman excises the head and severs the trochanter with its muscle attachments. The upper extremity of the femur is placed

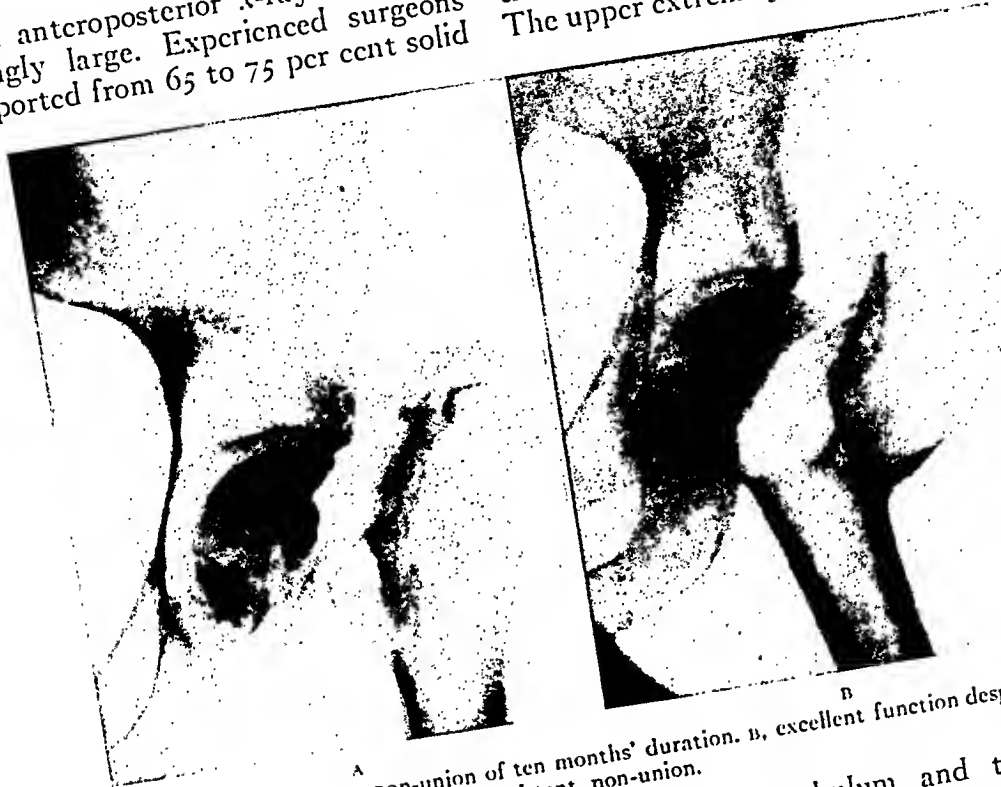


FIG. 6. Age 63 years. A, non-union of ten months' duration. B, excellent function despite persistent non-union.

bony unions, and a small percentage in which function was improved by a change in position and a strong fibrous union.

With the two view x-ray control that is now possible, bone graft of the femoral neck offers the hope of excellent functional results in carefully selected cases.

*Internal Fixation by Metal Nails and Pins.* Various metal nails and pins have been inserted by the same procedure as described for the insertion of the graft. There has not been a sufficiently large series by any one surgeon to evaluate the procedure properly. In a small number of cases the procedure has been used by the author. In one case, solid union was secured after two months and in one after eight months; however, in two others the procedure was not satisfactory.

*Reconstruction Operations.* Several operations for reconstruction of the hip joint have been devised. The exact procedure to be selected depends largely on the condition of the head and neck of the femur.

in the acetabulum and the trochanter transplanted lower down on the femoral shaft. Stability is maintained by the stretched abductor muscles.

Colonna excises the head and severs the abductor muscles at their attachment to the trochanter. He places the trochanter with its fibrous investment into the acetabulum, transferring the tendinous fibers of the severed muscles into the shaft of the femur at a lower level. Colonna claims that better motion is secured because of the fibrous investment of the trochanter.

Brackett removes most of the cancellous bone from the head and reshapes the neck, placing the denuded neck in contact with the excavated head. The trochanter with its muscle attachments is transplanted to a lower level on the lateral surface of the femur.

Albee removes the head and splits the greater trochanter from above downward, creating a greenstick fracture at the base of the trochanter. The trochanter with its



muscle attachments is bent laterally and a free graft of bone, either the denuded head or bone from the ilium, is wedged into the

discard crutches and to attend to the average demands of daily life. In many, the use of a walking cane adds materially to the



FIG. 7. Age 27 years. Traumatic dislocation of thirteen months' duration.

space. The medial portion of the trochanter and neck is placed into the acetabulum. No muscle attachments are disturbed, but the relaxed abductor muscles are shortened and their leverage action returned to normal.

L'Episcopo has recently devised a similar procedure which consists of doing a greenstick fracture of the inner third instead of the outer third.

The author has employed the same principle as that devised by Albee in two instances. The head was excised and shaped into a cube, and the trochanter severed and transferred to a lower level, the cube being inserted beneath the trochanter, thus securing better leverage for the abductor muscles.

The author has had personal experience with all of these reconstruction operations, and undoubtedly excellent results are secured when compared to the patient's former status. Most individuals are able to

endurance. In a small number of comparatively young individuals, almost normal activity is restored, but this is the exception rather than the rule.

*Osteotomies.* Osteotomy of the shaft of the femur is by no means a new procedure for ununited fractures of the femoral neck. This operation was employed by Lorenz as early as 1910, according to the author's personal knowledge, and later by Böhler and others.

Osteotomy may be done at the level of the lesser trochanter, or as advised by Schanz, at the level of the tuberosity of the ischium. The higher osteotomy is more often used in ununited fractures of the femoral neck, and is indicated as early as possible after the status of non-union has been discovered, and before marked absorption of the neck has taken place.

The procedure is carried out through a 3 or 4 inch longitudinal incision over the

## Campbell—Hip Joint

lateral surface of the trochanter and adjacent femoral shaft. The most desirable site is selected with x-ray control by the

cast is applied from the nipple line to the toes of the affected side and to the knee on the opposite side. An anteroposterior roent-



FIG. 8. Same as Figure 7, after formation of new acetabulum at higher level and remodeling of head. Excellent function.



FIG. 9. Age 3 years. Fifteen years after shelf operation for congenital dislocation of the hip.

insertion of a drill or Kirschner wire, and the femur severed with an osteotome. The distal fragment is then displaced inward beneath the head and the seat of non-union.

The operation can also be carried out as in the Gant's osteotomy, through a small incision at the base of the greater trochanter. A drill or Kirschner wire is inserted and the site of osteotomy selected by x-ray. The osteotome may be inserted on the drill or wire and the osteotomy made from below upward and inward at an angle of about 40 degrees. The lower fragment is displaced medially by manual force and abduction, aided, if necessary, by driving an impactor against the femoral cortex. The distal fragment should be displaced medially at least 1 inch. This can be determined by probing with a periosteal elevator or other blunt instrument, as the upper fragment can be felt to protrude externally. The exact position is confirmed by anteroposterior and lateral x-rays, and a plaster

genogram should then be made through the cast to confirm the position.

Even when the open operation is employed, roentgenographic control should be used, as failure to displace the distal fragment accurately defeats the purpose of the procedure.

Some surgeons employ transfixion nails in each fragment, incorporating the nails into the cast. This, however, is not necessary, as satisfactory position can be secured with external fixation alone.

The cast is removed at the end of two months and if union is solid, walking may be instituted with crutches or a Thomas caliper brace. Otherwise, a cast is applied with hinges at the knee for exercise of this joint.

The high osteotomy prevents the shearing action at the fracture site by displacing the weight bearing line inward so that the

femur finds a strong bony support above. At the same time the upper fragment is angulated outward increasing the leverage of the abductor muscles.

and the lower fragment is angulated medially so that it contacts the ischium. This position is maintained in a plaster cast until union is solid. The object is stabiliza-

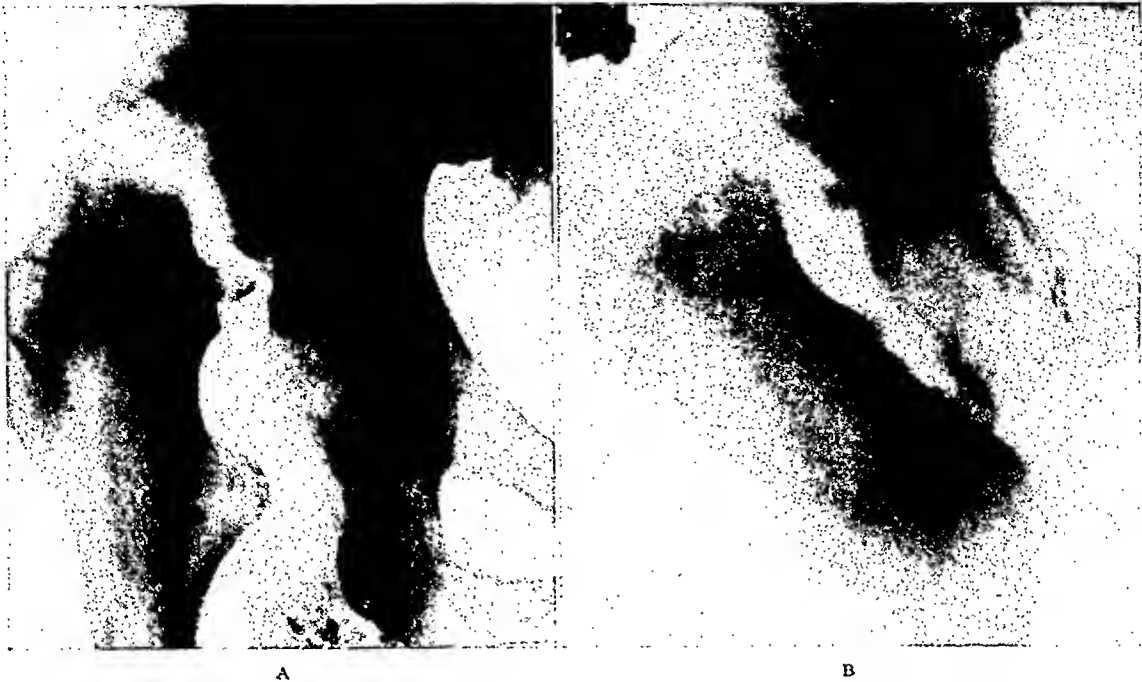


FIG. 10. A, Charcot joint. B, two years following Shantz osteotomy. Good functional result.

Solid bony union is secured at the site of non-union in many cases when the procedure is carried out early, or before there is absorption, or extensive changes occur. Even when bony union is not obtained, a stable, superior, osseous support is secured, which compares favorably with any reconstruction operation so far devised.

When bony union does occur, a most excellent result is secured. The patient may have 50 per cent or more of normal motion and almost normal endurance.

About four years ago, the author began to employ the procedure in debilitated or very aged patients. The results in these patients were so satisfactory that the scope of the procedure has been extended.

As a consequence of the excellent results obtained with this procedure, reconstruction operations are reserved for cases in which there is no neck and in which marked upward displacement of the trochanter exists.

The low, or Schanz osteotomy is made at the level of the tuberosity of the ischium

tion of the pelvis and femur, thus giving, indirectly, a superior support. The procedure is only indicated in those in which the neck has completely disappeared.

Both the high and low osteotomies have been advocated in fresh fractures of the neck of the femur and excellent results have been demonstrated.

The one disadvantage in the Schanz osteotomy is the occurrence of genu valgum as a result of strain on the internal lateral ligament of the knee joint.

The author has not had sufficient experience to evaluate the procedure. The late F. J. Gaenslen and his colleague, Schumm, have demonstrated excellent results in late ununited fractures of the neck of the femur and other mechanically analogous conditions.

*Fusion or Arthrodesis.* Gill has employed this measure in the treatment of ununited fractures of the neck of the femur with success. But, as Gill points out, a stiff hip should never be induced in the presence of arthritic changes in the spine.

*Pathologic Processes Causing Dissolution of the Head or Neck.* Dissolution changes in the head and neck of the femur as a result of various pathologic processes may produce exactly the same mechanical status as is found in ununited fractures of the neck of the femur. The causative agents are pyogenic infection, tuberculosis, aseptic necrosis, etc. If there is sufficient head and neck, a modified arthroplasty may be carried out, with restoration of the acetabulum of sufficient size to maintain the reconstructed head. At the same time a longitudinal osteotomy of the trochanter and outer third of the shaft may be made with displacement outward of the fragment, filling the space with a graft from the ilium. Mechanically, this elongates the neck and restores more normal leverage for the abductor muscles. When there is no head or neck, reconstruction operation, or osteotomy, or fusion, as above described, may be employed.

*Congenital Dislocation of the Hip.* In congenital dislocations which have passed the age in which satisfactory reductions are possible, three types of operation have been advised: (1) formation of a shelf on the dorsum of the ilium to give support to the head; (2) the formation of a new acetabulum and a shelf above the site of the normal acetabulum; (3) Lorenz bifurcation osteotomy. In the first two a satisfactory result, as emphasized by Dickson, requires the placement of the head forward on the dorsum of the ilium in line with the normal acetabulum. The results of this procedure, in our experience, after the elapse of six months to one year, were apparently unsatisfactory, but after two or more years proved to be surprisingly good. The Lorenz osteotomy or bifurcation operation consists of an osteotomy at the site of the acetabulum, from without, inward and upward, which has been modified by Haas from below upward and forward, avoiding any danger of injury to the femoral vessels. The lower fragment is displaced into the acetabulum in abduction, and union is secured between the two fragments. Putti, who is a

strong advocate of this measure, and has had more experience in congenital dislocations than any living individual, states that the operation should not be done before the age of 15, for before this period growth may nullify the mechanical effects.

In traumatic dislocations of long duration, as in old congenital dislocations, reduction is impossible, and the following operative procedures are usually advised: (1) the acetabulum may be enlarged upward and the head made smaller, after which reduction may be accomplished. Excellent motion is usually secured, but stability is far from satisfactory. A fusion of the hip, if the patient will submit, would be more desirable. (2) The second type of operation is the Lorenz or Schanz osteotomy.

*Paralytic Dislocation of the Hip.* In paralytic dislocation the problem confronting the surgeon is maintaining the head of the femur within the acetabulum and giving it ample superior support. Reduction is never difficult; in fact this can usually be accomplished by the patient.

Many operative procedures have been devised to stabilize the paralytic hip, most of them based on the principle of the shelf operation mentioned above. The following procedure was devised by the author and has been employed for many years with satisfactory results. A curved wood-carver's chisel is inserted above the acetabulum, breaking loose the entire superior portion with the articular cartilage attached; this is then pulled outward, extending the roof of the acetabulum laterally. Osseous flaps of raw bone are turned down from the dorsum of the ilium and one massive graft is removed from the crest of the ilium and forced into space above the extended acetabulum. Osseous union of the grafts with the acetabulum usually occurs in about sixty days, thus giving support to the upper extremity of the femur with material restoration of function and increased efficiency. This definitely improves the limp and also increases endurance, but the paralysis remains as a potential dis-

ability. In certain cases, the stability of the hip may be further improved by muscle transplantation at the same operation, or later, as devised by Legg and Dickson and others. When the tensor fasciae femoris is active it is transferred to the posterior portion of the crest of the ilium.

*Charcot Joints.* Charcot joints are an exceedingly difficult problem, and the results of surgery far from satisfactory. On account of the osseous structure fusion is improbable. Reconstruction operations may materially improve ambulation, but rarely is permanent relief secured. Probably the Schanz osteotomy, which is done in an area of normal bone, offers the greatest

hope. The author has secured an apparently satisfactory result in only one case by this method.

#### CONCLUSIONS

Operations for stabilization of the hip are legion, on account of the great frequency of occurrences of the various agents which induce instability. No one procedure can be adopted in all cases but proper surgical measures must be selected to meet the requirements of the individual case. Low and high osteotomies are at present being extensively employed with the report of favorable results, but more time is required before the actual status can be determined.



THE importance of being slender is greater than surface beauty . . .  
The thin are healthier and happier and live longer.

# SURGERY OF THE FOOT IN INFANTILE PARALYSIS

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THE predominant purpose underlying surgical operations on the foot is to restore, as far as possible, the function of the foot in standing and locomotion. This presupposes an accurate knowledge of the anatomic structures of the leg and the foot, the muscles, the bones and the joints with their ligaments, and a comprehension of the mechanical function of each structure alone and in coördination with all the others.

In anterior poliomyelitis, commonly known as infantile paralysis, there may occur a partial or a complete paralysis of one muscle or even of all muscles of the leg. While the physician in charge of the patient during the acute and the convalescent stages of the disease endeavors by proper splinting to put the weakened muscles at rest and to prevent the development of deformities, and while he endeavors during the stage of recovery to restore power to the affected muscles by suitable exercises and other methods of treatment, yet the patient frequently arrives at the final stage with certain residual and permanent paralysis. The problem then becomes a purely orthopedic one.

## DEVELOPMENT OF DEFORMITIES

Deformity of the foot develops. This is due essentially and primarily to muscle imbalance. Its form and its severity are entirely dependent on the extent and the degree of muscle weakness and paralysis.

A muscle which is unopposed or but feebly opposed by its natural antagonist will pull the foot in a definite direction. This pull is a constant one because it is caused by the normal physiologic tone or contraction of the normal muscle fibers and

is entirely independent of any volitional activity of the muscle. At first the muscle contraction and the resulting deformity are functional. The muscle can be stretched and the deformity overcome. But as time passes both become structural and permanent. This is due to the fact that when a muscle is permitted to remain in a continued state of contraction its fibers become structurally shortened and cannot be stretched and elongated to the normal extent. The foot, or certain parts of it, thus become fixed in an abnormal position. If the opponent muscles had any residual power they lose it because of the constant overstretching of their fibers.

The bones of the foot, particularly in the rapidly growing child, will soon become altered both in their shape and their architecture in accordance with Wolff's law. The ligaments of the joints become elongated on one side and shortened on the opposite side. Thus, eventually the deformity involves the essential structures of the foot and it may no longer be corrected by lengthening contracted muscles.

The malposition of the foot, while due primarily to muscle imbalance, is exaggerated by the bearing of the body weight. The foot is not placed properly beneath the weight-bearing line and the superimposed load thrusts it still farther away from this line in the direction of the primary deformity.

The development of deformity of the foot is accompanied by a corresponding impairment of function. The instability of the foot and the abnormal strain upon that part of the foot which is obliged to bear the entire weight of the body because of the shift in the weight line make standing and walking difficult. And, because the function

of one or more muscles has been destroyed, the normal power and elasticity of locomotion is impaired. The development of painful calluses at the sites of friction and pressure still further adds to the disability of the foot.

#### DESCRIPTION OF DEFORMITIES

Deformities of the foot can arise because of the natural movements which are possible in its joints. (This, of course, is aside from malpositions which occur because of fractures, dislocations and loss of bony substance.) When any joint becomes fixed in any other than the normal position for weight bearing and locomotion or when it assumes a position which is beyond the individual's control on standing and walking, we call this condition a deformity. Some deformities are constantly present while others are apparent only when the person puts his weight on his foot.

*Physiologic Movements of the Foot.* The movements of the ankle joint are best designated as *dorsal* and *plantar flexion* (bending) of the foot. This avoids the confusion which may arise by calling plantar-flexion extension of the foot, inasmuch as it is produced by the flexors of the ankle and the toes, and the opposite movement (erroneously called flexion of the ankle) is produced by the extensors of the ankle and the toes.

*Supination* and *pronation* correspond with the similar movements of the hand and occur when the os calcis and the scaphoid rotate around the longitudinal axis of the astragalus. The calcaneo-astragalar and the astragaloscaphoid joints move in unison during this function and therefore are considered surgically as one, the subastragalar joint.

*Inversion* (internal rotation) and *eversion* (external rotation) also occur in the subastragalar joint.

*Adduction* and *abduction* denote movements of the forefoot and take place in the midtarsal or Chopart's joint (the astragaloscaphoid and the calcaneocuboid joints).

*Plantar* and *dorsal flexion* of the anterior part of the foot also occur largely in the midtarsal joint.

Certain of these movements of the foot may occur in coördination with one another, such as inversion and supination, eversion and pronation, etc.

The movements of minor joints need not be considered here.

The author may add that there is considerable confusion in textbooks concerning the use of these terms and that supination and inversion or inversion and adduction are used synonymously, for example. This may all be avoided by adherence to the above nomenclature.

#### DEFORMITIES OF THE FOOT

*Talipes Equinus.* Plantar flexion on weight bearing, due essentially to contracture of the tendo Achillis, is complicated at times by contracture of the posterior ligament of the ankle, deformity and subluxation of the ankle and contracture of the flexors of the toes. The author has seen this deformity so severe that the patient bore her weight on the dorsum of the foot and wore a shoe with the toe pointing backward behind the leg.

*Talipes Calcaneus.* This is dorsal flexion or heel walking, and may be so severe that the heel lies in front of the weight-bearing line of the tibia. Often combined with marked cavus (hollow foot).

*Talipes Valgus.* Pronation and eversion of the foot. Weight is borne largely or entirely on the inner side of the foot.

*Talipes Varus.* Supination, inversion and, sometimes, adduction of the foot. The opposite of valgus.

*Talipes Cavus.* Hollow foot. The top of the arched foot is at the midtarsal joint. By some authors this deformity is divided into two types: (1) *arcuatus*, in which the os calcis is tilted upward in front and the forefoot is dropped; and (2) *plantaris*, in which the forefoot drops at the midtarsal joint, but the os calcis is in normal position, or even tilted downward in front.



## Gill—Infantile Paralysis

Talipes Planus. Flatfoot. This often accompanies valgus.

Talipes Adductus. Adduction of the forefoot. Concavity of the inner side of the foot.

Flail Foot. Complete paralysis of the foot. Dangle-foot.

Drop Foot. Either a dangle-foot or a talipes equinus.

Claw Foot. Prominence of heads of metatarsals, hyperextension of proximal phalangeal joints and flexion of interphalangeal joints, combined at times with some degree of cavus.

Various combinations of these deformities may be present, as calcaneovalgus, calcaneocavovalgus, equinovarus, etc.

Furthermore, lateral deformity may occur in the ankle joint. When a valgic foot has been subjected to long-continued weight bearing the outer portion of the astragalus is narrowed from top to bottom. When the foot is plantar-flexed the valgus disappears because the outer part of the astragalus drops down within the ankle joint and the outer portion of its articular surface is no longer in contact with the tibia. On dorsiflexion the foot goes into astragalus ascends and the foot goes into valgus. There is a rotation of the malleoli within the mortise of the ankle.

It must be remembered that all of these various types of deformity arise primarily from muscle imbalance and that after surgical correction they may recur if balance is not restored.

The surgeon should have a thorough knowledge of the normal construction and mechanics of the foot and an understanding of the causes and the elements of the various deformities and disabilities before he attempts reconstructive operations.

Orthopedic surgeons have made many mistakes in the past. Many operations at one time popular have now fallen into disuse because they were not fundamentally sound. It has taken a good many years of observation and study to evaluate the various surgical procedures that have been proposed and employed and to design new

ones better fitted to secure permanent correction of deformities and optimal restoration of function.

## OPERATIVE PROCEDURES

It will be impossible in a paper of moderate length to enumerate and describe all the operations that are employed in treating the deformities and disabilities of the foot caused by infantile paralysis, and to give due credit to all surgeons who have made contributions in this field of surgery. Attempt will be made to state and explain the principles underlying the various types of surgical procedures and to mention those pioneers who enunciated them or aided essentially in establishing their application to surgery; to illustrate the common deformities and to point out not only the uses but also the abuses of standard operations.

Tenotomy and Fasciotomy. Stromeyer usually receives the credit for establishing the value of tenotomies in the correction of contractures. His method of subcutaneous division of the tendo Achillis enabled him usually to avoid the infections which almost invariably followed the open operations in use in his time, and, consequently, tremendously broadened the field for this procedure.

Its purpose is to secure a definite lengthening of a structurally shortened muscle in order to correct a deformity which is due in whole or in part to the contracture of this muscle. Other structures such as fasciae, ligaments and capsules of joints and malformed bones may resist and prevent correction after tenotomy has been done.

Tenotomy does not increase the power nor extend the function of the muscle. The range of tendon movement is less than normal because the shortened (contracted) muscles fibers have not been lengthened. Muscle strength is likewise subnormal because these same fibers are in a state of physiologic contraction and cannot undergo further volitional shortening to produce movement. Therefore, an overlengthening of the tendo Achillis to correct equinus may

lead to the more disabling deformity of calcaneus. Possibly, too, the dorsiflexors of the foot may recover some power on relief of the overstretching which has been produced by the prolonged plantar flexion of the foot and contribute to the production of calcaneus. On the other hand, the original deformity may recur if the triceps surae is still in the process of structural shortening or if the bones of the leg are growing longer.

Therefore, tenotomy of the tendo Achillis to relieve a disabling talipes equinus should not be performed during the earlier period following the attack of infantile paralysis. It should be done only when a lengthening of the muscle fibers cannot be obtained by manipulation, sufficiently gently to avoid rupture of muscle substance, or be secured by gradual stretching by the use of apparatus or turnbuckle casts.

Overlengthening may be avoided by the open z method of lengthening with suturing together of the two ends after the desired correction of the deformity has been made. An equally effective result may be obtained by subcutaneous divisions of the two halves of the tendon at the desired distance from each other and forcible stretching to cause one half to slide upon the other to the necessary extent.

There are comparatively few cases following infantile paralysis where an equinus is not combined with a lateral deformity of the foot. In these cases the tenotomy must be accompanied or succeeded by a foot stabilizing operation. And, since a subastragalar arthrodesis produces some bony shortening below the ankle with relative lengthening of the tendo Achillis, a tenotomy may be unnecessary.

It should be borne in mind that a moderate fixed equinus aids in stabilizing the knee in cases of paralysis of the quadriceps femoris muscle.

In conclusion, one may say that tenotomy or formal lengthening of the tendo Achillis is not indicated except in children who have not yet reached the age when arthrodesis may be done or in combination

with this latter operation at the proper time.

Tenotomy or even resection of other tendons, for example, the peronei and the tibialis posticus, may be indicated in the correction of lateral deformities or for the prevention of relapse.

*Fasciotomy* of the plantar fascia is useful in the correction of hollow foot. The author subcutaneously cuts the fascia free from its attachment to the internal tuberosity of the os calcis. Many surgeons use the open stripping method of Steindler.

*Muscle Transplantations and Transferences.* One of the earlier developments in the modern surgical treatment of infantile paralysis was the attempt to restore muscle balance of the foot by transplanting the insertion of muscles or by transferring the direction of their action by the formation of a pulley around which the tendons would glide. The names of Nicoladoni, Codivilla, Vulpius, Lange, Mayer, Steindler, and others stand out in this field.

In the course of a few years outstanding limitations and contraindications to these methods of operation became apparent. It was very difficult to reestablish a complete muscle balance. To estimate accurately the exact mechanical power of any muscle or group of muscles is painstaking and dubious. To compute its power and its physiologic function when transplanted to a new position is even more difficult. And to find a muscle which after transplantation is of just the precise strength to balance the foot against its antagonist, if it then has an antagonist, is practically impossible. The entire matter is exceedingly complicated.

Tendon transplantation presupposes also that all other elements of the deformity are first eliminated, as a transplanted muscle will not overcome contracted ligaments and muscles and correct malshaped bones.

The technique of operation is exacting in order to preserve as far as possible the normal direction of pull of the tendon, to maintain the normal tone of the muscle fibers which might be disturbed by over-

## Gill—Infantile Paralysis

stretching or over-relaxation, to prevent adhesion of the tendon to surrounding structures and to avoid injury to its blood supply, as well described by Mayer.

A transplanted muscle may be able to produce volitional movement when the foot is at rest, but may be inactive during the act of locomotion. It may not act in coördination with all other muscles, as it does naturally when in its normal position. A transplanted muscle may lose some of its natural strength because of a too great load placed upon it.

No wonder that failures to secure correction and that relapses and overcorrections and development of new deformities from added disturbance of equilibrium so frequently followed these operations.

Generally speaking, therefore, muscle transplantation and transference is useful only in combination with other corrective and stabilizing types of operation. It is necessary even after fusion, or arthrodesis, operations to have some semblance of muscle balance in the foot lest the original deformity recur. The author, years ago, called attention to the lateral deformity which may develop in the ankle joint following effective subastragalar arthrodesis and due to the continued pull of the pronators and evertors of the foot. When the normal mechanical function of a muscle is destroyed by a fusion of the joint which that muscle moves, the tendon should be transplanted to a position where it may have a useful function. This principle will be illustrated later.

**Neurotization.** To reënergate paralyzed muscles would be the ideal treatment. This procedure has been investigated by Erlacher and others; but insuperable difficulties have been encountered that, thus far, render it impracticable.

**Tenodesis.** The fixation of a tendon into bone to make it serve as a ligament to prevent or to limit certain movements of the foot has been employed by Codivilla, Putti, Gallie and others. The most useful field of tenodesis has been in the correction of talipes calcaneus either alone or, prefer-

ably, in combination with other operative procedures that produce backward displacement of the foot and also correct lateral instability.

**Arthrodesis, or Fusion of the Foot.** Fusion of two or more bones of the foot is performed to correct deformity and to effect a permanent stabilization in the normal weight-bearing position with regard to the foot as a whole in relation to the leg and with regard to the position of the bones of the foot in relation to one another. Arthrodesis is often the only means that will accomplish these two objectives. Part of the flexibility of the foot is sacrificed for stability which is so essential for weight bearing. Joint motions in the foot are of no practical value unless they can be controlled or unless the bones remain in normal relation to one another on standing and walking.

**Arthrodesis of the Ankle.** Albert originated this operation in 1878, and the technique has been frequently modified by other surgeons. It was used chiefly to correct talipes calcaneus. Of course, it has applications other than in infantile paralysis, but this paper is dealing only with the latter. After Whitman (1901) and Davis (1913, 1916) showed the value of posterior displacement of the foot in the correction of calcaneus, arthrodesis of the ankle fell for the most part into disuse.

It has certain vital defects except in a limited number of cases. The foot is converted, in effect, into a peg-leg, rigid and inelastic. This objection may in part be overcome if the foot is ankylosed in slight plantar flexion so that the ball of the foot may first strike the ground and permit the movement of the tarsal joints to compensate for the absence of movement in the ankle, and to permit the wearing of a shoe which has a heel of the usual height.

Since calcaneus is frequently accompanied by lateral deformity and cavus, arthrodesis of the ankle will not solve the whole problem. Other operations, such as the Whitman astragalectomy or the Davis horizontal transverse section with back-

ward displacement of the foot, will correct all elements of the deformity.

The employment of arthrodesis to correct the drop of the flail foot is ill-advised, as there are better operations for this condition.

Ankle arthrodesis may be useful, as taught by Davis, in stabilizing the knee when the quadriceps femoris is paralyzed. If the ball of the foot first strikes the ground while the ankle is fixed the weight of the body tends to force the heel downward and drive the knee backward. A moderate contracture of the tendo Achillis produces the same mechanical effect.

Steindler's panastragalar arthrodesis is a fusing of the ankle and the subastragalar joints. The indications for these two operations (ankle and subastragalar arthrodeses) are entirely separate and distinct. The author has objected to Steindler's nomenclature as tending to confuse and obscure the essentially different and clearly defined indications for the two operations. Furthermore, the term is superfluous, as each of the two operations was already firmly established among surgical procedures. And, finally, the combination of the ankle and subastragalar fusions renders the foot more rigid than may be necessary.

On the whole, the author believes that arthrodesis of the ankle has little or no place in reconstruction operations on the foot in infantile paralysis.

*Subastragalar Arthrodesis.* This is probably the most useful of all operations on the foot. While the literature demonstrates that Nieny first advocated it (1905) yet G. G. Davis independently originated an operation to stabilize the foot by this method. He published his first paper in 1913, but the author has found in the records of the Orthopaedic Hospital in Philadelphia a description of the operation written in 1907 in his own handwriting together with pencil sketches to illustrate it. Davis, probably, was most influential in establishing the principles underlying the operation and in demonstrating its usefulness, and during a time when other sur-

geons in America were doubting or denying its efficacy and were still using tendon transplantation and tenodesis only in the operative correction of deformities except for an occasional arthrodesis of the ankle by the method of Goldthwait (1908).

Numerous modifications of Davis' method and different ways of performing the arthrodesis have been devised since Davis' earlier work, but all have for their one object the fusion of the astragalus, the os calcis and the scaphoid in the position essential to normal weight bearing. It is useful in the permanent correction of the lateral deformities of the foot and in the stabilization of flail foot.

Arthrodesis of the subastragalar joint by any operative method is accomplished by completely removing the articular cartilage from the three bones which enter into this joint. The forefoot is then placed in proper alignment with relation to the longitudinal axis of the astragalus and the os calcis, which carries the forefoot with it, is set normally beneath the astragalus. The foot is maintained in a plaster cast for a period of twelve weeks until the fusion is accomplished. Great care must be taken by any method to mould the foot properly before the plaster sets.

Lateral muscles such as the peroneus brevis and the tibialis posticus, if strong, must be resected or transplanted to positions where they may be useful in active plantar or dorsiflexion of the foot. The arthrodesis destroys their natural function, and they should not be left to bring about any recurrence of lateral deformity.

Arthrodesis should usually be postponed, if possible, until the child has reached the age of 9 to 12 years, as before this period the bones are too cartilaginous in their structure.

When the lateral deformity of the ankle, which has already been described, is present, the author corrects it by raising the superior articular cartilage of the astragalus from the outer side and inserting into the cleft a wedge-shaped piece of bone removed from the astragalus or the os

calcis while doing the subastragalar arthrodesis. Thus the normal shape of the astragalus is restored within the mortise of the ankle.

The triple arthrodesis of Ryerson consists of a subastragalar plus a calcaneocuboid arthrodesis. It is useful in lateral deformity accompanied by talipes cavus, extreme planus or adductus.

*The Correction of Talipes Calcaneus.* Whitman (1901) first demonstrated the necessity for displacing the foot backward below the ankle. He accomplished this effectively by removing the astragalus (astragalectomy). The tibia was then brought forward to rest upon the foot near the midtarsal joint. The peroneal muscles (when valgus was present) were transplanted into the os calcis. The talipes cavus was corrected when the foot was displaced backward. When this operation has been confined to those cases of calcaneus and calcaneovalgus for which Whitman designed it the results have been very satisfactory. Its efficacy depends on several factors: (1) the displacement of the tibia forward prevents the anterior part of the foot from tilting upward; (2) the tarsus comes in contact with the anterior lip of the tibia and acts as a bone-block to dorsiflexion; and (3) the ligaments of the ankle as they are displaced backward by their attachments to the foot act as posterior check ligaments. The transplanted peronei may partially restore muscle balance of the foot.

Davis, by his horizontal transverse section and backward displacement of the foot beneath the astragalus, applied the main principle of the Whitman astragalectomy without removing the astragalus and at the same time (by the subastragalar section, or arthrodesis) corrected the lateral deformity. The head of the astragalus is removed in this operation to permit the backward displacement of the foot. The peronei, if active, are transplanted to the os calcis. The author has modified the Davis operation by definitely stripping the lateral ligaments of the ankle (particularly the

external) from the lower portion of the malleoli, so that they will form strong posterior check ligaments, and by elevating the anterior superior articular cartilage of the astragalus and fixing it with a bone wedge to constitute an anterior ankle block in severe cases.

The Whitman and the Davis operations are both fundamentally sound and both will give splendid results if properly executed. Other operations based upon the same principles have been devised by a number of surgeons.

Putti (1922) also devised a method of constructing an anterior bone-block at the ankle.

*Flail or Dangle-Foot.* In this condition there is a complete paralysis of all muscles. The anterior part of the foot drops of its own weight, when it is raised from the ground. On weight bearing it turns frequently into a position of varus or valgus and is therefore unstable, although no fixed deformity is present in non-weight-bearing position.

Such a foot is well stabilized by a subastragalar arthrodesis and a moderate backward displacement of the foot to balance more nearly the heel with the anterior part of the foot.

*Drop Foot and Posterior Bone-Block.* The foot may drop either in the condition of flail foot just described or in the true talipes equinus (power in the tendo Achillis and paralysis of the dorsiflexors).

For the latter condition a posterior ankle bone-block is essential. Campbell first described (1923) a suitable operation for this deformity. He builds on the posterior superior aspect of the os calcis a mass of bone that by contact with the posterior and inferior surfaces of the lip of the tibia prevents plantar flexion of the foot.

The author described (1933) another method to accomplish the same result. The posterior half of the articular cartilage of the astragalus is lifted up and held firmly against the inferior surface of the tibia with a bone wedge driven in solidly beneath the cartilage. This wedge is removed from the

posterior superior part of the os calcis. It is the same method by which the author had been accustomed to make an anterior bone-block.

*Talipes Cavus.* This deformity occurs in the midtarsal joint and may be efficiently corrected by a midtarsal arthrodesis with the excision of sufficient bone from the surfaces of the astragalus and the scaphoid and from the os calcis and the cuboid to permit complete correction.

In very young individuals the deformity may be cured by a division of the plantar fascia at its attachment to the tuberosity of the os calcis and a manual manipulation of the foot.

The severe cases require both a fasciotomy and an arthrodesis.

*Talipes Planus.* The severe and disabling type of flaccid flat foot can be cured by astragaloscaphoid arthrodesis with moulding of the foot.

#### CONCLUSION

The author has tried to make clear the fundamental principles of the various common deformities of the foot in infantile paralysis and to describe, briefly, within the limitations of this paper, certain operations which are in general use and are successful because they were devised and executed in conformity with these principles. Space has not permitted to give due credit to the many surgeons who have contributed essentially to the development of this field of surgery and who have aided in establishing it upon a firm basis.

It must be remembered that a paralyzed foot, no matter how free of deformity or how well stabilized, is never as good as the normal foot, and that the object of all operations, whatever method the surgeon may employ, is to bring about, as far as possible, a return of the foot to its normal appearance and its normal weight-bearing function.

The surgeon is advised to study carefully the literature on this subject that he may be familiar with the underlying principles and with the operative technique. A brief bibliography is appended which should serve but as a basis for much more extensive reading.

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# TENDON TRANSPLANTATION IN THE UPPER EXTREMITY

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## I. PRINCIPLES

IN the first period after its introduction in the early nineties tendon transplantation had a strong attraction for the orthopedic surgeon, with the result that it became applied much too promiscuously and soon after fell into disrepute. However, in the course of years, the restrictions and limitations of the method had become well established by long clinical studies and extensive experimental work. There are restrictions which apply to tendon transplantation in general; and there are, in addition, others which apply to the upper extremity in particular.

The principles which govern the practice of tendon transplantation are so well established and are so consistently cited in all treatises on the subject that it is hardly necessary to refer to them at great length.

1. A previously existing contracture must be completely corrected because no tendon pull can prevail against an already established shortening of muscles or other soft tissues. It must be possible, after the tendon transference is performed, to bring the limb passively through the range of motion without the slightest resistance.

2. The muscles must be properly chosen. Long and parallel-fibered muscles are particularly suitable for replacement. The muscle selected for replacement should have a similar or otherwise related action. The use of a straight antagonist as a substitute is somewhat doubtful because of the difficulty in rearranging of voluntary impulses through the central nervous system. What is the possibility of reeducating the muscle to its new function? In the upper extremity fortunately the movements are so complex that almost every one of the long muscles has a part with some component or other of its function in almost any motion of the wrist; if it is not

actually engaged in producing the motion it may function as a stabilizer of the wrist. Consequently, in the upper extremity the possibility of reeducating the muscle is vastly greater than in the lower extremity, and there is, consequently, a greater latitude in selecting muscles for transplantation.

On the whole, however, it may be said that the natural function of the muscle should not be radically changed when it is used for tendon transplantation, and it is believed (Scherb) that the presence of an active antagonist is an obstacle to the transplanted muscle.

3. The integrity of the muscle unit must be respected. It is not possible to educate portions of the same muscle to act as antagonists against each other; in other words, to reverse the action of part of the muscle. This has been tried by splitting the tendo Achillis in the hope of letting one half act independently of and antagonistically to the other half. This is a physiologic absurdity which never does lead to an operative success.

4. The transplanted muscle must have adequate muscle power; that is to say, it should in strength compare favorably with the one for which it is to substitute. As a rule this can be accomplished only approximately. But it is more important in the lower than it is in the upper extremity because weight bearing is a very exacting demand and because stability plays such an important part in the function of the joint; so that, unless the transplanted muscle is at least approximately equal to the one it substitutes, stabilization becomes insufficient and deformity follows. One should always keep in mind that in the long muscles, because they run almost parallel to the long axis of the limb, the stabilizing component is always greater than the



rotatory component which carries out visible motion. In the upper extremity the problem of stabilization is much less important than that of mobilization. Therefore, muscles can be used for mobilizing the wrist or fingers which would be otherwise entirely inadequate for stabilizing purposes; for instance, the palmaris longus can be used for the abductor of the thumb. In other words, the fact that in the upper extremity the stabilizing element is in the background makes the application of tendon transplantation much wider than in the lower.

5. The Leverage. In the mechanical arrangement of the transplanted tendon one must take care that the tendon pull is in a straight line, or, if the line of pull changes direction, it must be so deflected by a pulley through which the tendon may glide freely. This is particularly important in the upper extremity where the system of pulleys and vincula, which ordinarily deflect tendons from a normal course, may be imitated by surgical reconstruction. For instance, in the tendon transplantation of Bunnell for the substitution of the paralyzed thenar muscle, use is made of an artificial pulley constructed at the pisiform bone through which the deflected tendon or deflection of carpi ulnaris is led to the base of the thumb.

It is because it is so important to provide straight lines of pull that we have to use long incisions, so that the tendon may be mobilized sufficiently and may follow a straight course without kinking. Such mobilization of the tendon, of course, interferes somewhat with the blood supply which it receives from the surrounding tissues. This disadvantage, however, can be avoided by carefully refraining from stripping the tendon and by taking along as much of the gliding apparatus, the paratenon, as possible.

6. The next requirement is that the tendon must be transplanted under suitable tension. It is obvious that if the tendon is relaxed in the position in which it is anchored, not much further contraction of

the tendon can be accomplished, and, therefore, the range of motion from that position may be small. The tendon should always be given a suitable tension, and even under anesthesia a certain degree of moderate tension should be applied in the position in which the tendon is sutured. It is a rather empirical matter to decide upon the degree of tension. It depends largely upon the amount of antagonistic muscle which is present. For instance, if we transfer a tendon from the flexor group to the dorsum of the wrist, and if the remaining flexors are acting strongly, it is obvious that a greater amount of tension is necessary than in the cases where the wrist flexors are of lesser strength. The increased tension of the tendon makes the joint more set, more closely knit, so to speak. There will be a greater range of motion where both flexors and extensors will be under a certain degree of positive tension, one group relaxing and the other increasing its tension, according to which direction motion is carried out.\*

7. Anchorage. The type of anchorage which is now universally preferred is the periosteal or bony attachment of Lange, wherever such anchorage is possible. That is to say, the tendon should be anchored preferably in the bone by means of a drill hole canal.

In the upper extremity it is often necessary to attach tendon to tendon because the transplanted tendon is not long enough to reach to the point of attachment. It has been argued that the paralyzed tendon stretches, but this opinion is lacking in proof, and stretching occurs rather in the paralyzed muscle belly. Where stability is of secondary consideration such tendon attachment is entirely sufficient. It is not sufficient, however, in the lower extremity where the periosteal or transosseous attachment is definitely to be preferred. Where tendon-to-tendon attachment is carried out the best way of anchorage is through the button-hole suture, leading the tendon

\* STEINDLER, A. *Mechanics of Normal and Pathological Locomotion*. (Thomas, 1935.)

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through an opening in the receiving tendon and then anchoring it by lateral sutures. For end-to-end suture we definitely prefer the technique of Bunnell.

8. The Gliding Apparatus. It is essential to preserve the gliding apparatus for the tendon, as a tendon deprived of a gliding surface is not suitable for function. This has been brought out by Codivilla who originated the so-called tendon sheath exchange method, recognizing the importance of the preservation of the sheath for the gliding action of the tendon. Biesalski and Mayer subsequently elaborated the tendon sheath exchange technique, and Bernstein has gone so far as to advocate the transference of the tendon together with the sheath. One must decide how far of the gliding apparatus and how far nature itself can provide for it. We find that in the upper extremity sufficient gliding facilities are provided when the tendons are led through subcutaneous tunnels. Adhesions are much more likely to follow if the intra-osseous route is taken, for instance, between the forearm bones or if the tendon is placed tightly under the vaginal fascia.

## II. THE APPLICATION OF TENDON TRANSPLANTATION TO THE UPPER EXTREMITY

In the upper extremity there are certain definite situations suitable for tendon transference.

A. *The Substitution for the Paralyzed Deltoid.* The first prerequisite is the preparatory correction of the adduction or inward rotation contracture. Conservative methods are to be preferred. These contractures are on the whole of lesser importance and only seldom require operative release of the adductors, i.e., the pectoralis major and the latissimus dorsi, or of the inward rotators, especially the subscapularis. At present we have no reliable method of tendon transplantation for the paralyzed deltoid, and we, therefore, on the whole prefer the arthrodesis of the shoulder joint. However, the newer tech-

nique of the method of Mayer as well as the transplantation method of Ober promise fairly good substitution for the paralyzed deltoid.

Mayer's technique is essentially mobilization of a portion of the trapezius and implantation of this portion into the insertion of the deltoid muscle.

Technique. (1) From a longitudinal incision the acromial portion of the trapezius is mobilized. (2) It is then enveloped in a fascial sheath in such a manner that the portion of the fascia lata recovered from the thigh is laid under the separated portion of the trapezius muscle; then another portion of fascia is used to cover it; and the continuation of this fascial sheath, used as tendon of insertion, is led through the deltoid muscle to the point of insertion of the latter. We are not certain that under this condition the portion of the trapezius will function independently.

The method of Ober consists in detaching the origin of the pectoralis major from the thorax, freeing it over the shoulder, where it is sutured to the spine of the scapula with the arm held in abduction. Another method by the same author uses the short head of the biceps and the long head of the triceps as abductors by transferring the tendons of origin of these muscles to the acromion.

While either of these methods may give some definite improvement in the abduction of the arm, on the whole we find that the tendon transplantations for the paralyzed deltoid are rather unreliable.

B. *Tendon Transplantation for Loss of Supination at the Elbow.* Any existing pronation contracture must be corrected. This can be done readily by splints, or by operation upon the pronator radii teres or quadratus if necessary.

Tendon transplantation for the paralysis of the supinators is indicated in infantile paralysis, in paralysis of the musculospiral nerve, in the pronation contracture of spastic paralysis, or ischemic paralysis, provided that the contracture itself has been previously overcome so that passive

supination is possible before the operation is undertaken.

The method of the writer is as follows:

The plan is transplantation of the flexor carpi ulnaris dorsally to the lower end of the radius.

1. A long volar incision is made along the lower half of the flexor carpi ulnaris, which muscle is exposed, dissected, and severed at its insertion to the pisiform bone.

2. A second, shorter incision is made on the dorsal surface toward the lower end of the radius, between the extensor indicis tendon and the long extensor tendon of the thumb. The lower end of the radius is then exposed.

3. With a long obstetrical forceps a subcutaneous tunnel is made obliquely from the dorsal incision over the dorsum of the forearm, to come out on the volar side at the upper pole of the volar incision.

The flexor carpi ulnaris is now drawn from its point of origin obliquely over the dorsum of the forearm to the lower end of the radius.

4. Then a tunnel is drilled in to the lower end of the radius and the flexor carpi ulnaris tendon is made to enter into the tunnel from the dorsal side so as to come out at the volar end of the tunnel. It is then reflected back and sutured to itself. In this manner the action of the flexor carpi ulnaris is reversed, and it acts now as an active supinator. We prefer this method to Tubby's procedure in which the pronator radii teres and the flexor carpi radialis are both led through the interosseous space dorsally and anchored to the radius.

Following the operation, the hand, forearm and elbow are placed in a cast with the wrist in slight dorsiflexion, the forearm in full supination, and the elbow flexed at right angle. After three weeks the cast is removed and substituted by a splint of the same length and position, and at the same time the after-treatment is begun. This consists in gentle massage and active movements. The splint is worn for a period of two to three months, being removed at

least twice a day for treatment and exercises. (Fig. 1.)

*Statistics.\** Twelve cases reported. Under the functional classification there were seven good results, one fair, and four poor. Of the four poor results, 2 may be attributed to too much surgery. One result was very good, with supination possible to a range of 80 degrees from mid-position, and pronation possible to 90 degrees from mid-position. In this case there was ability to supinate against resistance.

The correction of the deformity was good in seven cases and fair in five cases. The result was considered good when the transplant functioned actively through a useful arc, with at least 40 degrees of pro- and supinatory motion. The result was fair with a range of motion of between 20 and 40 degrees through a useful arc, and poor when there were less than 20 degrees of motion. Length of follow-up averaged 3.6 years.

*C. Loss of Flexion at the Elbow.* This loss of flexion may be due to infantile paralysis, peripheral nerve lesion, or traumatic loss of the flexor muscles.

The principal flexor muscles at the elbow are the biceps, the brachialis anticus, and the brachioradialis. When these three muscles are gone, there remains only the group of the extensors of the wrist, the extensor carpi radialis longior and brevior, coming from the external epicondyle and the external epicondylar ridge, and the flexor group which arises from the internal epicondyle and the internal epicondylar ridge. While all these muscles have a flexory component acting upon the elbow joint, yet, because of the proximity of the muscle axis to the axis of the elbow their rotation moment is so small as to be negligible, and these muscles cannot to any satisfactory degree substitute for the loss of the principal flexors of the elbow joint.

In this situation there are only two practical plans: either to transplant the triceps

\* Compiled by Dr. A. W. Ciani, S.U.I., covering a period from January 1, 1926 to April 30, 1938 (Department of Orthopedic Surgery.)

to substitute for the paralyzed flexors, or to rearrange the origin of the flexors of the wrist about the elbow in such a fashion that

already mentioned principle of the integrity of the muscle unit and, therefore, physiologically not feasible.

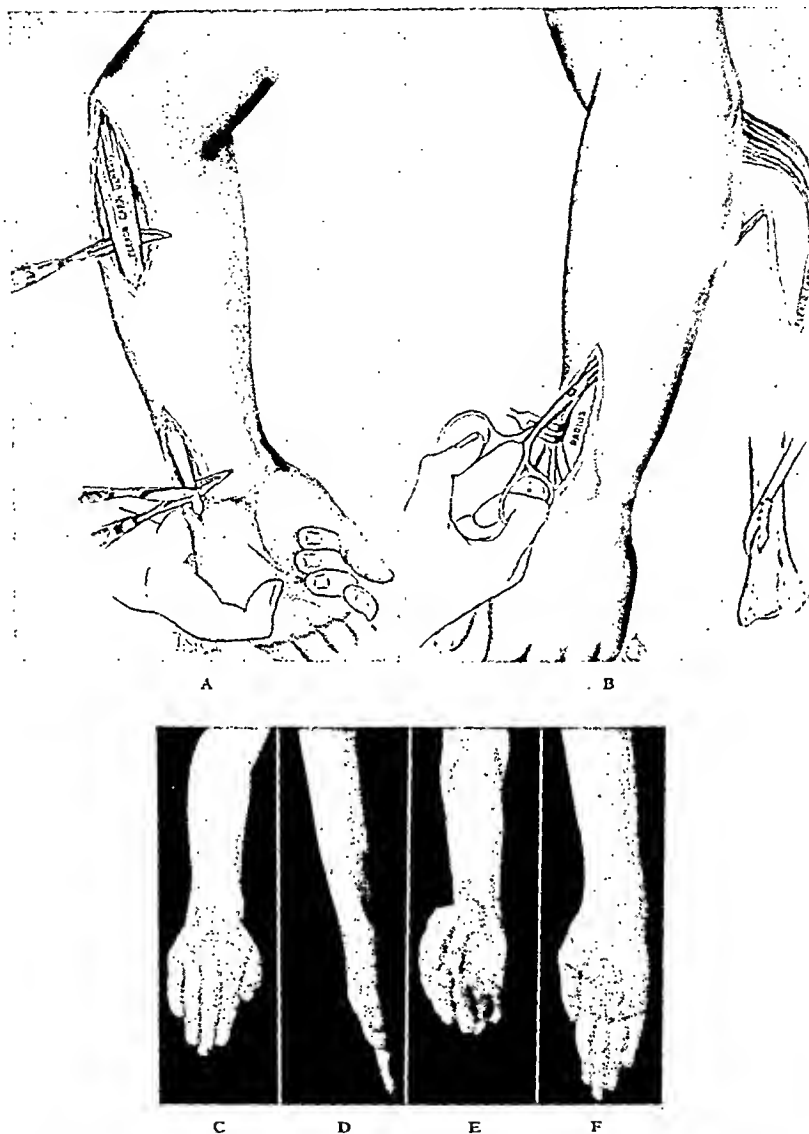


FIG. 1. Supination of the hand made possible by the transplant of the flexor carpi ulnaris to the distal end of the radius.

they develop a stronger moment of flexion in this joint.

1. The transplantation of the triceps muscle, although it has given occasional results, cannot be generally recommended, first, because of anatomic difficulties, and, second, because the loss of the normal function of the triceps is too great a sacrifice. On the other hand, the splitting of the triceps in an anterior and posterior half with opposing action is a violation of the

In this technique the common tendon of the triceps is separated downward and the dissected portion is transposed to the flexor side of the elbow. Physiologically, of course, it is better to transpose the entire muscle forward.

2. A method which has given us very much greater satisfaction and does not entail any sacrifice of muscle is the one used by the writer for about twenty years.

Operative plan: Transposition of the common origin of the flexors from the internal epicondyle to a higher level of

*Technique.* 1. Incision on the inner side of the humerus, 3 inches above the internal epicondyle, downward, between the brachi-

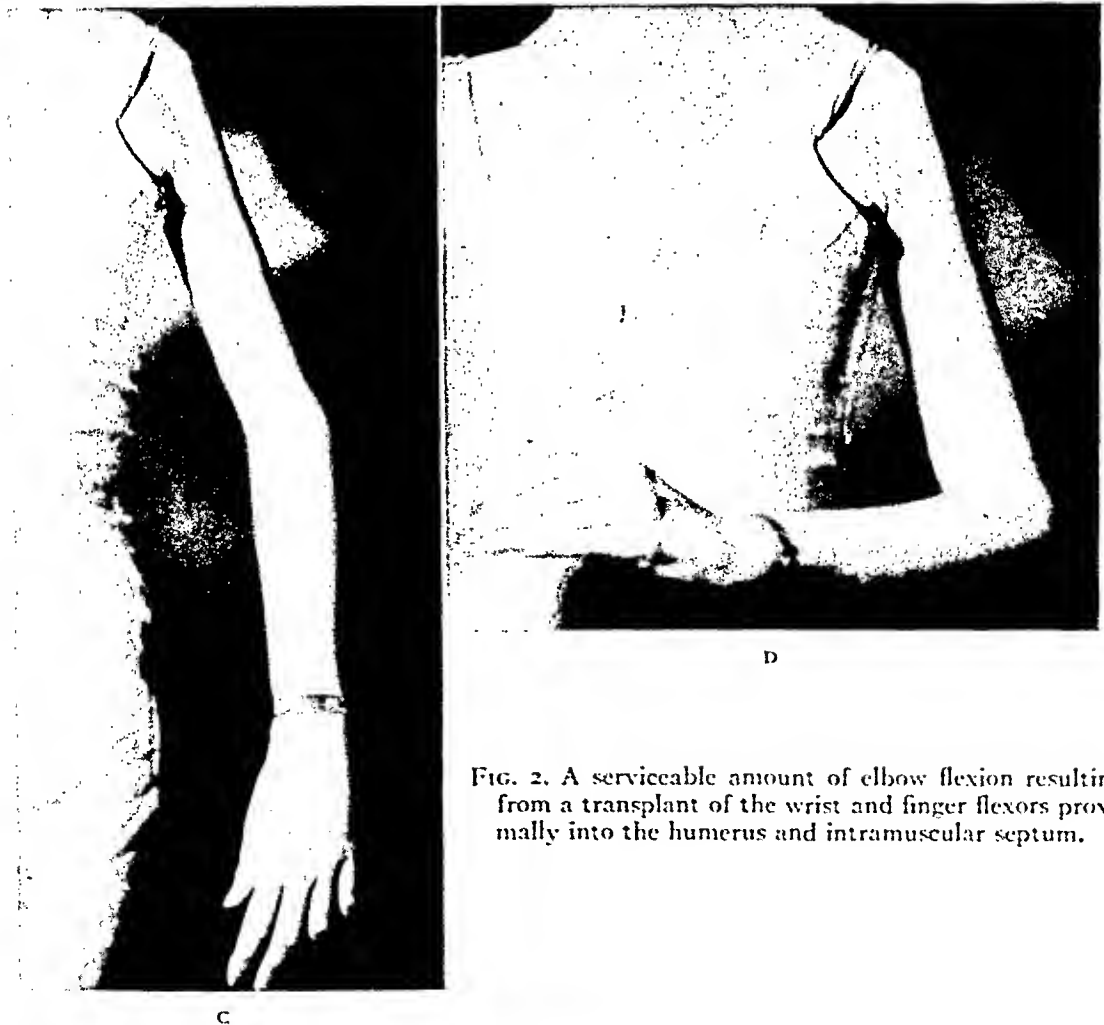
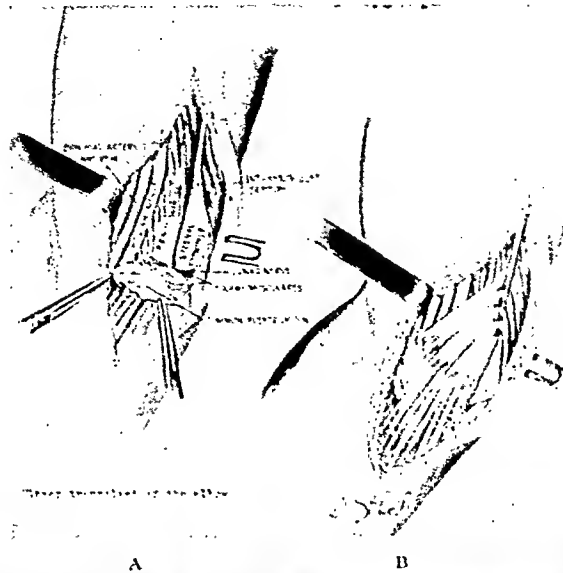


FIG. 2. A serviceable amount of elbow flexion resulting from a transplant of the wrist and finger flexors proximally into the humerus and intramuscular septum.

the humerus; the preservation of the muscle power of the flexors of wrist and fingers is a necessary prerequisite.

alis anticus and the biceps muscle, to the internal epicondyle, then forward and obliquely downward in the direction of the

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pronator radii teres, following the radial border of this muscle.

2. After dissection of fat and fascia the ulnar nerve is located, isolated, and carefully drawn backward.

3. The origin of the flexor muscles of the forearm at the internal epicondyle is carefully defined and dissected out, and the muscles are detached from the bone close to the periosteum in one single mass. This mass consists of the superficial head of the pronator radii teres, flexor carpi radialis, the palmaris longus, and the flexor carpi ulnaris. It is possible to strip these muscles down as far as  $1\frac{1}{2}$  inches from the internal condyle, at which point the median nerve is seen to send its branches into the muscles.

4. The muscle flap so obtained is now free enough so it can be lifted up and transposed upward, 2 inches above the condyle, into the humerus. For this purpose, the intramuscular septum between triceps and brachialis anticus is followed until the external epicondylar ridge of the humerus is felt, and the humerus is then carefully dissected subperiosteally, and two drill holes from front backward are placed in the humerus about at the level at which the muscle flap is to be placed. Chromic catgut is passed through the drill hole and through the edge of the muscle flap, and the muscle flap is anchored firmly to the humerus. At this point the elbow will be found in acute flexion and it must be held in supination. In this position the arm is placed in a cast.

This cast must be changed in not more than three weeks in order to lessen the flexion of the elbow gradually, and it is then supplanted by an adjustable splint which allows the gradual diminishing of the flexion position. The after-treatment begins with the removal of the cast and consists in active motion, careful massage and muscle training.

It is essential for the success of this operation that the flexor muscles of the wrist show good or normal strength. Because the operation is likely to accentuate an existing pronation tendency, this must be checked by appropriate splinting, and

any pronation contracture must have been previously corrected. The power gained by this operation for flexion of the elbow is only moderate but patients are able to carry light objects to the mouth.

If the operation is combined with the arthrodesis of the shoulder, however, as in cases with combined shoulder and elbow paralysis, the advantage of the operation becomes much more obvious. The arm can now be raised to the horizontal position and in this position, since there is no forearm weight to be carried, the flexion of the elbow is very much easier. Our newer statistics on the results of these flexor plasties of the elbow, involving 29 of these operations, give a total of 79.8 per cent good results, 6.8 per cent fair results, and 13.4 per cent poor results; the good results being those in which there is at least 60 degrees of active motion through a useful arc, so that the patient can get the hand to the mouth and extend the arm to at least 120 degrees, and has no pronation contracture.

The failures occur usually in cases in which the flexors of the wrist and fingers are too weak, that is, too severely paralyzed to warrant the transplantation, which was the case in three of our patients; or, as has occurred in one case, the transplanted muscles may pull loose from the new attachment. Here a second operation was necessary, and this gave an excellent result. With the technique of drill-hole anchorage, such an occurrence is not likely to happen. (Fig. 2.)

*D. The Flail Wrist or Drop Wrist.* The paralytic wrist drop may be due to musculospiral palsy, to infantile paralysis, to ischemic contracture, or to spastic paralysis.

The previously existing contracture must be corrected, and very often this is possible by conservative means. In exceptional cases the resistance of the flexors is too great for correction by passive stretching and the flexors of the wrist must be lengthened to restore normal position. Wherever upon the correction of the flexion contrac-

ture a spontaneous return of the power of the extensors cannot be expected, then tendon transference of the flexors to the extensors is indicated. What type of operation is to be performed depends largely upon whether or not sufficient muscle material is available to give both stability and mobility to wrist and fingers. The muscles available for transplantation must not only satisfy the static and dynamic needs of the wrist and provide extension of the fingers, but also, if possible, abduction and extension of the thumb.

For such a purpose one needs at least three good and strong individual flexor muscles. In isolated paralysis, such as in the musculospiral or in its branches, it is possible to requisition three good flexor muscles; but in infantile paralysis very often such muscle material is not available.

*The Special Technique.* (a) Sufficient material is available.

Substitution by the method of Robert Jones. The operative plan is the transposition of the flexor carpi radialis, of the pronator radii teres, and the flexor carpi ulnaris to the extensors of wrist and fingers.

We use the palmaris longus instead of the pronator teres.

*Technique.* 1. From a long volar incision the flexor carpi radialis, the palmaris longus, and flexor carpi ulnaris are isolated as far distally as possible. From a smaller, dorsal incision over wrist and lower forearm the compartments for the common extensors, the long extensor of the thumb, and the abductor longus and extensor brevis pollicis are opened and the tendon exposed.

2. The flexor carpi radialis is then swung around the radial border to be united and fastened to the extensor pollicis longus.

3. The palmaris longus is swung around the radial border to be united to the abductor pollicis longus and extensor pollicis brevis.

4. The flexor carpi ulnaris is swung around the ulnar border, led through the compartment of the common extensors, and split up in several slips which are united

individually to the four extensor tendons of the fingers.

The after-treatment requires complete plaster immobilization with wrist and metacarpophalangeal joints in extension position for a period of two weeks. The ends of the fingers must be left out of the cast since the extension of the interphalangeal joints is not a function of the extensors but one of the lumbricales and interossei. Massage and active motion begin early, with the healing of the wound. The cast is removed after two weeks and immediately substituted by a splint holding the fingers in the same position. This splint should be worn for six months. (Fig. 3.)

Our series of cases of tendon transplantations performed for infantile paralysis showed 80 per cent acceptable results. Failures were due to errors in indication and technique, and especially to errors in the after-treatment.

We do not favor the institution of active motion within a few days after operation, but it is advisable to start massage not earlier than the eighth or tenth, preferably the fourteenth day, and then only with the greatest precaution. Active motion may be allowed from the eighth day in the bivalved cast or through a window in the cast.

(b) The muscle material available is not sufficient for both dorsiflexion and stabilization of the wrist.

It appears that some stabilizing method must be added, either the ligamentous suspension or tenodesis, or the arthrodesis. Of these two we much prefer the arthrodesis because the tenodesis does not stabilize the wrist but merely suspends it in extension. The arthrodesis, however, stabilizes the wrist definitely in the desired position of slight extension. We found that this combination of arthrodesis with tendon transplantation gives fairly satisfactory results, although not as good, of course, as in those cases in which sufficient muscle material is available for both motion and stabilization.

*E. The Thenar Palsy or the So-Called Flat Thumb.* The paralysis of the thenar



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muscles arises from infantile paralysis, from peripheral paralysis, from traumatic separation of the ulnar nerve, or from an

We must distinguish between the pure opposition of the thumb in which position the thumb is simply opposed to the finger

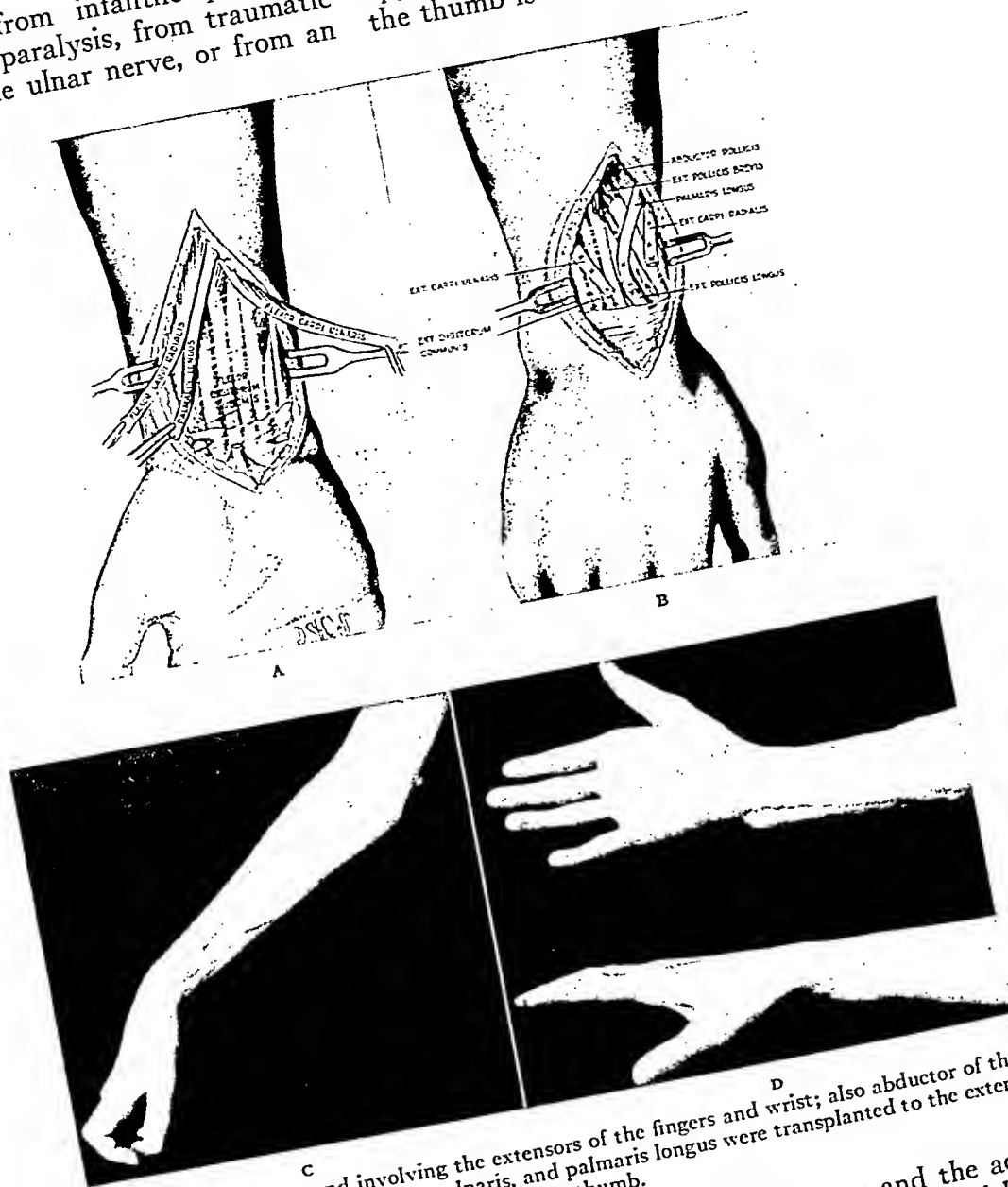


FIG. 3. A shot-gun wound involving the extensors of the fingers and wrist; also abductor of the thumb. The flexor carpi radialis, ulnaris, and palmaris longus were transplanted to the extensors of the fingers, wrist, and abductor of the thumb.

ischemic contracture. The paralysis of the thenar muscles incapacitates the hand to a considerable degree as the most primitive movements of the hand depend upon opposition of the thumb. This opposition may be substituted by the adductors of the thumb and the long muscles, but it is as a rule impossible for the thumb to meet the tip of the index or middle finger.

at a certain distance; and the adduction-opposition of the thumb in which position the thumb is not only opposed but is also adducted and pronated against the finger. The former position requires the action of the abductors of the thumb, particularly the abductor longus and extensor brevis, in addition to opponens action, and may be considered to be the first part of the entire

circumductory movement of the thumb. In order to bring the thumb into full circumduction there must follow upon the former movement also the adduction and flexion in the metacarpophalangeal joint (short flexor action).

All these motions are eliminated in the thenar palsy and must be substituted.

In the method used by the author this substitution is carried out by a part of the long flexor of the thumb. This is split and the radial half of it is anchored to the base of the basal phalanx. This second tendon attachment has the effect of both an adductor and an opponent, and of a flexor of the metacarpophalangeal joint, and it substitutes all the elements of complete abduction-opposition which had been lost by the thenar palsy.

The technique is as follows:

1. An incision is made on the radial side of the thumb from the middle of the end-phalanx down to the middle of the thenar, so as to avoid the motor branches entering from the median nerve.

2. The long flexor of the thumb is now exposed through this incision, its sheath is excised, the edges of the sheath being secured by fine forceps.

3. The tendon is lifted out of its sheath and split longitudinally the full length of the incision. The outer or radial half of the tendon is severed at the distal end of the split and reflected upward and the sheath of the long flexor tendon is reunited over the remaining ulnar half.

4. The radial tendon flap is now carried around through a tunnel made in the soft parts and led out through a point at the base of the basal phalanx well upon its dorsoulnar side.

5. A short incision is made at this point through which the tendon is led out. The periosteum of the base of the basal phalanx is exposed and a tunnel is made through the base through which the tendon half is passed, reflected and fastened to itself. In this manner it encircles the proximal phalanx of the thumb.

6. The dressing is applied as follows: The thumb must be held in the position of opposition and adduction and the end-phalanx of the thumb must be flexed.

This position is of importance for function. Flexion of the end-phalanx is necessary in order to relax the half of the long flexor of the thumb which has remained in situ. Unless this is done, the contraction of the common tendon of the long flexor of the thumb will produce a flexion of the end-phalanx before the thumb is circumducted, making the opposition of the thumb to the tips of the fingers impossible. The procedure simply provides a second attachment for the flexor of the thumb so that when this muscle contracts the tendon flap brought around the thumb causes it to swing around in opposition with the trapezium as a pivot. The thumb is then able to approach the little finger and carry out gripping motions.

Two points are essential: (1) That the tendon of the flexor pollicis longus is split long enough, from the base of the end-phalanx down to the middle of the metacarpal, in order to get a long enough flap which can be carried around the base of the basal phalanx in oblique direction, corresponding to the direction of the opponens pollicis. (2) The other point, already mentioned, is that the thumb be dressed in opposition with the end-phalanx flexed.

The principal condition for the success of the operation is that the flexor pollicis longus must be well preserved.

Statistics on the end results of the flexor plasty of the thumb:\* Good or excellent results obtained in 72 per cent, fair results in 5.5 per cent, and failures in 22 per cent.

The causes of failures were inadequate strength of the flexor pollicis longus, failure of proper anchorage, and deficient after-treatment, that is, failure to secure the thumb in opposition with the end-phalanx flexed. These factors are avoidable and

\* Compiled by Dr. J. B. Davis, S.U.I., Department of Orthopedic Surgery.

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there is no reason why this operation should not give a uniformly good result. (Fig. 4.) The method of Bunnell is based upon

to the pisiform bone. The operative plan is to take one of the flexor tendons of the forearm which is run through a pulley

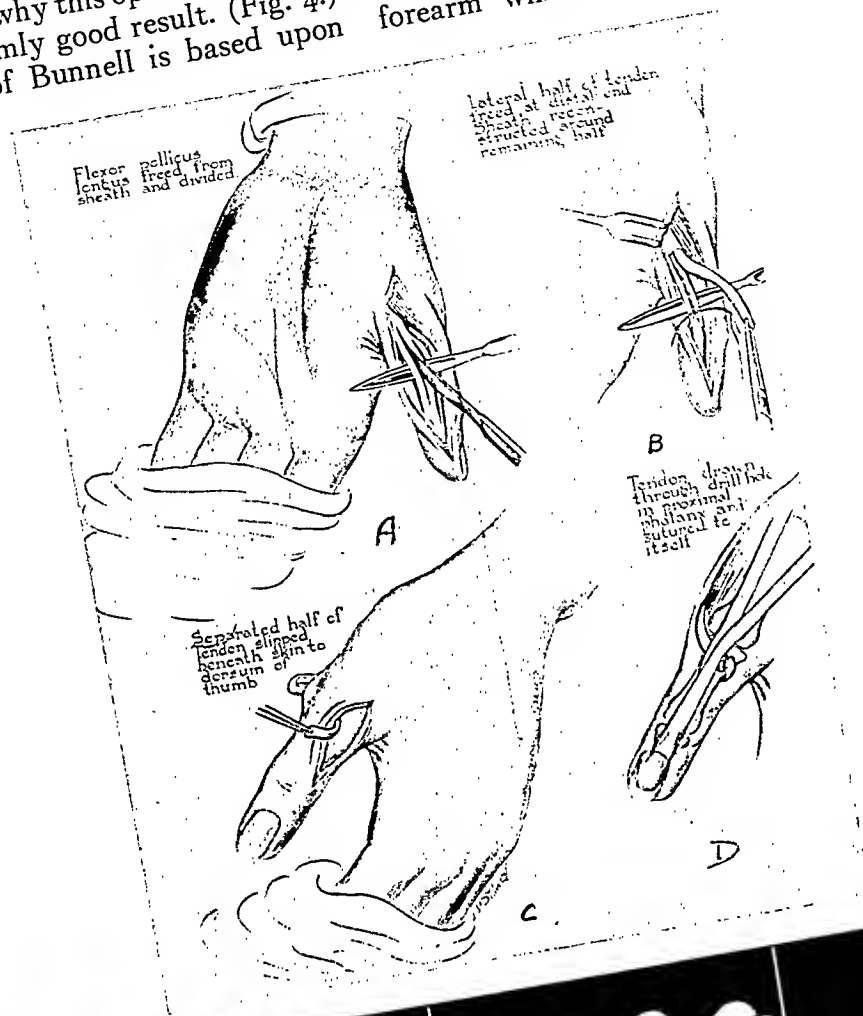


FIG. 4. Flexorplasty of the thumb. A and B, range of motion possible in the thumb before operation. C, opponent action carried out by the transplanted portion of the flexor pollicis longus.

the conception that to reconstruct the opposition the pull must be in line from back of the distal end of the first phalanx at the pisiform bone. From there the tendon or its prolongation by a free graft is passed subcutaneously to the dorsum of the

distal end of the metacarpal of the thumb into a drill hole through which the tendon end is looped and sutured to the tendon. Bunnell uses the flexor carpi ulnaris for the muscle and the flexor palmaris longus partly for the pulley and partly for the prolongation of the flexor carpi ulnaris, so that it may reach the point of implantation at the base of the distal end of the metacarpal of the thumb.

The method of Ney makes use of the action of the palmaris longus. The extensor pollicis brevis is severed above the level of the volar carpal ligament and its peripheral end is led volarly through a subcutaneous tunnel under the volar carpal ligament, and is then united with the tendon of the palmaris longus.

#### CONCLUSIONS

On the whole, the field of tendon transplantation in the upper extremity is much wider than it is in the lower, because of the preëminence of the mobilizing function of muscle action over the stabilizing. This does not mean, however, that the stabilizing component is negligible. On the contrary, in transferring the wrist flexors to the extensors of the fingers, for instance, we must definitely count upon the stabilizing effect of these muscles on the wrist, because without it movement of the fingers would be weak and uncertain. It merely means that in the upper extremity the requirements of stability are not nearly so exacting as they are in the weight-bearing joints. The second point in favor of the upper extremity is its greater adaptability to new function; that is, the muscles can reverse or change their original function in a much broader sense than they can in the lower extremity.

On the other hand, because of these conditions, the after-treatment of the tendon transplantation operations in the upper extremity is undoubtedly more complicated and more intricate than it is in the lower. I should like to emphasize in this respect two points:

1. Do not start any kind of motion in tendon transplantation until at least two weeks after the operation, and then only active motion in the gentlest possible manner.

2. When splints are applied it must be remembered that in the upper extremity postural contractures occur very much sooner and are very much harder to combat than in the lower. It is our custom, therefore, not to leave the same splint on continuously, but to alternate with others which hold the fingers in a reversed position. For instance, splints holding the fingers in complete extension, as employed in transplantation of flexors to extensors, should never be left on for an entire day but should be alternated with others which allow slight flexion of the mid- and end-phalangeal joints. Otherwise, capsular contracture in these articulations will produce extension deformities which are extremely hard to overcome.

It must be realized how delicate the balance is between extensor and flexor groups and that such balance can only be maintained by the action of the intrinsic muscles of the hand. Consequently, in the absence of these muscles there is a constant tendency to develop contractures and one must forever be on guard against them.

The outlook for tendon transplantations in the upper extremity is quite hopeful and the field is large. The indications must be made very judiciously and only upon careful analysis of the muscle dynamic situation.

Every technical detail must be carried out with even greater care than in the lower extremities because interference with free function of the tendon occurs so easily.

Finally, the end result of the operation stands and falls with the after-treatment. Many cases look very promising after the cast is first removed, but frequently the result is lost because of the inadequate or improper postoperative care.

# TENOTOMY, ITS INDICATIONS AND TECHNIQUE\*

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**T**ENOTOMY is the section of a tendon for the correction of a deformity and was first performed in the early part of the seventeenth century by Min-  
nius, Roonhuysen and others, and again in 1784 by Thilenius, Lorenz and Sartorius. These earlier operations were all done by the open method and are recorded as quite successful. However, it was early recognized that the infection which followed the open method (commonly ascribed to the effects of exposure to air), tended greatly to delay the recovery of the case, and, by the resultant scarring, to complicate the final results in many instances. In 1816, Delpech performed the first successful subcutaneous tenotomy on a case of clubfoot, but the operation did not become popular until Stromeyer, in 1831, showed that it could be done almost with impunity. This period marks the real beginning of tenotomies in orthopedic work. To William Little of London, belongs the credit of its success in England. He was afflicted with double congenital clubfeet and visited Stromeyer who, by cutting both heel tendons, secured sufficient correction to permit Mr. Little to walk upon the soles of his feet (though the varus deformity persisted). The relief obtained by Little made him an ardent advocate and follower of the procedure and gradually the opposition of English surgeons was overcome and the operation became of wide and general use.<sup>1</sup>

The indications for the operation are malformations due to muscle contractions

or shortenings and any muscle dysfunction which, if permitted to persist, will result in shortening and cause either temporary or permanent deformity in the actuated part. Also, in cases of muscle imbalance, whether from lesions in the central nerve system or from local spasm of persistent type, tenotomy is a most valuable procedure in the effort to restore balance.

The operation is naturally divided into two methods, the open and the closed (or subcutaneous) and each may be said to have its own particular indications. However, the anatomic knowledge and surgical skill of the operator commonly prove the determining factors in the selection of the method to be used. The open method is chiefly employed in those areas in which there is danger of injury to important structures (such as at the base of the neck for wry neck, the folds of the axilla, the adductors of the thigh and the internal and external hamstrings at the knee) while in superficial areas and structures, with prominence of the tendon, the subcutaneous is the method commonly employed. The comparison of the advantages of the two procedures is shown in the following table:

Open	Closed
1. No danger of injury to neighboring parts.	1. Danger in certain areas.
2. Accuracy in lengthening.	2. Less so.
3. Each step of operation visible.	3. Invisible.
4. Certainty of apposition of tendon ends.	4. Uncertainty.
5. In tendons having a synovial sheath, this method must be used.	5. Contraindicated unless the sheath is very short (toes, etc.).

<sup>1</sup> The facts regarding William Little were given to the writer by the late E. Muirhead Little of London, who was internationally known for his work in orthopedic surgery.

The disadvantages may be listed as follows:

- | Open   | Closed                 |
|--|------------------------|
| 1. Greater danger of infection.  | 1. No danger.          |
| 2. Length of time necessary for performing the operation.  | 2. Quickly done.       |
| 3. Large amount of scar tissue.  | 3. Practically none.   |
| 4. Subsequent adhesions about the tendons frequently interfering with the after-excision of the tendon.        | 4. None.               |
| 5. Scar in the skin may be unsightly (as in the neck) or may be irritated by the clothing (as above the heel). | 5. Absent.             |
| 6. In the event of reoperation, greater difficulty is encountered.   | 6. Practically absent. |

In the hands of the experienced surgeon, the closed procedure has practically superseded the open and the disadvantages are seen to be almost negligible. The selection of the proper knife for the subcutaneous operation is of importance. The type commonly offered for sale by the instrument dealers is entirely too large and in using it, much greater damage is done to surrounding structures than is necessary or desirable. The cutting blade should not be more than  $\frac{1}{2}$  to  $\frac{5}{8}$  inch long, need not be more than  $\frac{1}{16}$  inch wide, and must be thick enough to avoid danger of breaking. One's equipment should include several sharp-pointed and several blunt blades. The shank between the blade and the handle should vary from 1 to  $2\frac{1}{2}$  inches in length. The handles may be square or flat, but should have a dull or rough finish rather than a smooth plating. This allows a firmer grasp of the knife and guards against slipping. Another essential factor is that the blade shall be sharp. If it is sharp and the tendon is held tense, very slight contact of the knife with the tendon will sever it, while if dull, greater effort will be needed and the blade may be broken by the pressure necessary to cut the tendon.

The type of open operation which has been used for nearly fifty years is that described and published simultaneously by

Dr. Keen of Philadelphia and Mr. Anderson of Ireland, originally called the Anderson-Keen method, and now known as the "Z" method. It consists in (1) the exposure of the tendon by a sufficient incision through the skin directly over or by the side of the tendon and free separation of the tendon from its tissue sheath. (2) The tendon is then split either anteroposteriorly or laterally for the desired distance (2 or 3 inches); (3) one-half is cut off at one end and the other half at the other end. Then, (4) by pulling upon the distal or attached end, the two parts are slipped past each other for the desired distance and (5) one or two sutures are placed to hold the tendon ends in lateral apposition. (6) The skin incision is evenly closed and a splint of plaster or other firm material is applied to fix the part in the corrected position until firm union occurs.

This same lengthening, in a tendon without a synovial sheath, can be accomplished subcutaneously by putting the tendon in tension, (7) insertion of a sharp-pointed tenotome through the skin at the upper end of the tendon and piercing it near the center. The tenotome is then turned at a right angle and one-half of the tendon is severed. The knife is withdrawn and reinserted 1 or  $1\frac{1}{2}$  inches below and the other half of the tendon is severed. Firm corrective pressure is made upon the distal part of the tendon attachment and the fibers of the tendon (which are parallel) easily slip past each other and allow the required amount of lengthening to be accomplished. (8) This procedure is extremely simple and most satisfactory in cases of superficial tendons. If, however, the tendon fibers are twisted (as sometimes occurs in the Achilles tendon) the knife should be reinserted at one or the other end, a few more fibers severed and full correction secured.

Where section of the tendon is desired and preservation of its fibrous continuity is not essential, the tendon is put under tension and a sharp-pointed tenotome is inserted through the skin, preferably at the

## Rugh—Tenotomy

side of the tendon. The blade of the knife is pushed forward with the flat side next to the tendon, either on the upper or on the

secure and maintain full correction may result in pressure sores which may, in turn, vitiate the ultimate results of the opera-

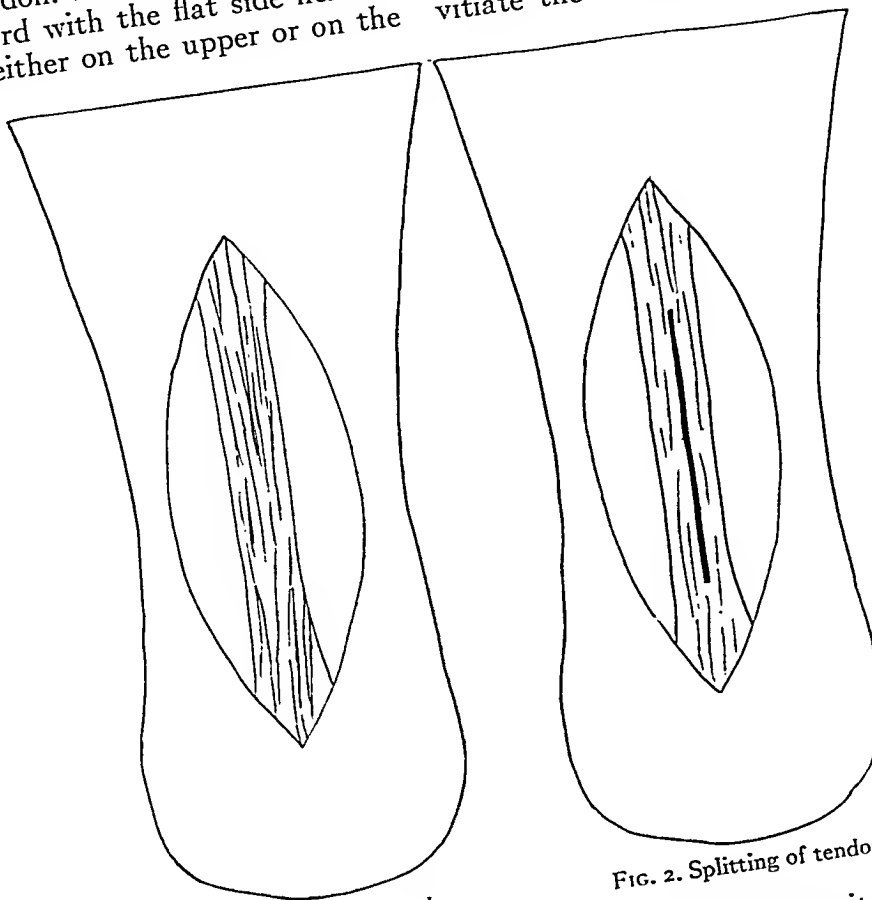


FIG. 1. Exposure of tendon.

FIG. 2. Splitting of tendon.

under surface as seems desirable to the operator. The knife is turned with the cutting edge against the tendon and with a sawing motion the tendon is severed. By the use of extension-pressure, the ends are separated sufficiently to permit correction of the deformity. The wound is covered with a small gauze dressing and the fixative agent or apparatus is applied at once to maintain correction.

If possible, complete rather than partial lengthening of the tendon should be secured at the time of operation, though the changes in the surrounding tissues and nearby bones and joints and the tension upon neighboring vessels and nerves, may render full correction either inadvisable or impossible. When the resistance of the surrounding tissues (including the bony structures) is pronounced, attempts to

tion. In such cases, it is much better to complete the correction by stages, increasing the pressure every five or six days according to the reaction of the local tissues until the desired result is obtained.

When tendon lengthening was first employed, there was considerable diversity of opinion regarding what happened to the tendon ends and how great were the dangers of nonunion. Extensive experiments upon animals were early made by Paget (Lectures on Surgical Pathology, London, 1853) and since verified by many others, which demonstrated that union occurred by the pouring out of a lymph-like fluid which became organized and formed a continuous structure, almost indistinguishable from tendon tissue, between the tendon ends. Nonunion of a tendon without a synovial sheath occurs but rarely and



full correction of the deformity should be accomplished at once if possible.

Healing of the tendon is usually com-

axillary region and of the adductors of the thigh as, in these areas, scar tissue forms quickly and, unless thorough stretching is

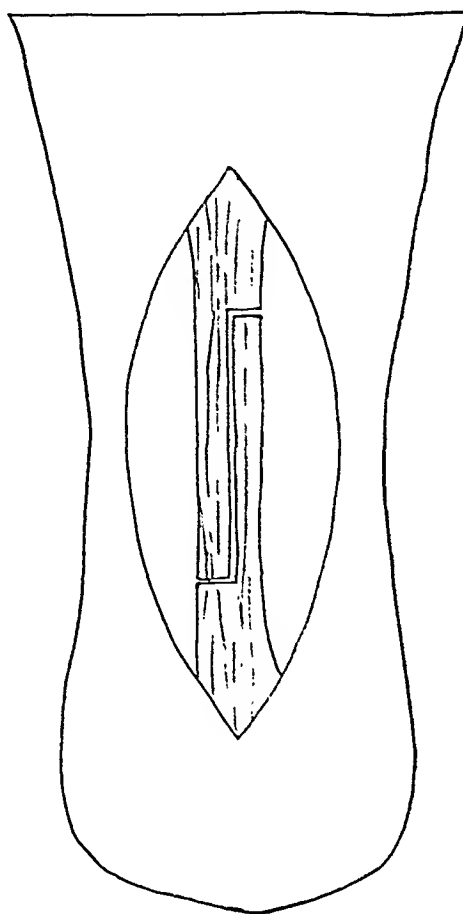


FIG. 3. Cutting of opposite ends.

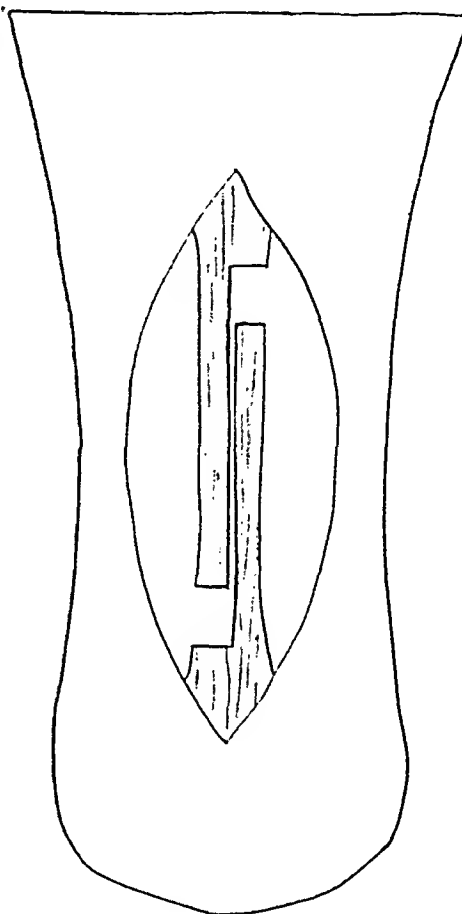


FIG. 4. Lengthening by extension pressure.

plete in three weeks and after this time, a gradual return of function is permitted and encouraged. This gradual use of the part (where the tendon performs an important function, as in the tendo Achillis) stimulates healing and a firmer organization of the reparative tissue though if too free use is allowed, the cut area will develop greater thickening from proliferation of surrounding connective tissue cells than if function is resumed more slowly. The amount of function permitted will depend greatly upon the site of the operation and the importance of the structures severed. In cases of torticollis, massage of the sternocleidomastoid muscle should be begun in two or three days so as to insure full muscle lengthening and thorough stretching of the surrounding fasciae. The same procedure is followed in section of the muscles in the

maintained, recontraction will take place promptly. In the case of tendons having synovial sheaths, motion should not be attempted for from two to three weeks as firm union of the tendon ends is essential to the after function of the part and too early efforts at function may separate the ends and prevent healing. A similar precaution applies to the tendo Achillis because of the tremendous strain put upon this part in the function of walking and subsequent danger of overstretching or nonunion.

The surgery of the synovial sheathed tendons is a specialty in itself and requires great skill and meticulous care in its performance and follow-up. Unless the surgeon is skilled in dealing with these tissues, he should be very loath to undertake such an operation, and even in the correction of

congenital or acquired deformities due to muscle shortening, one should realize the exceeding importance of the after-care and such cases corrective measures through muscle action are lost. Experience has shown that growth and development oft-

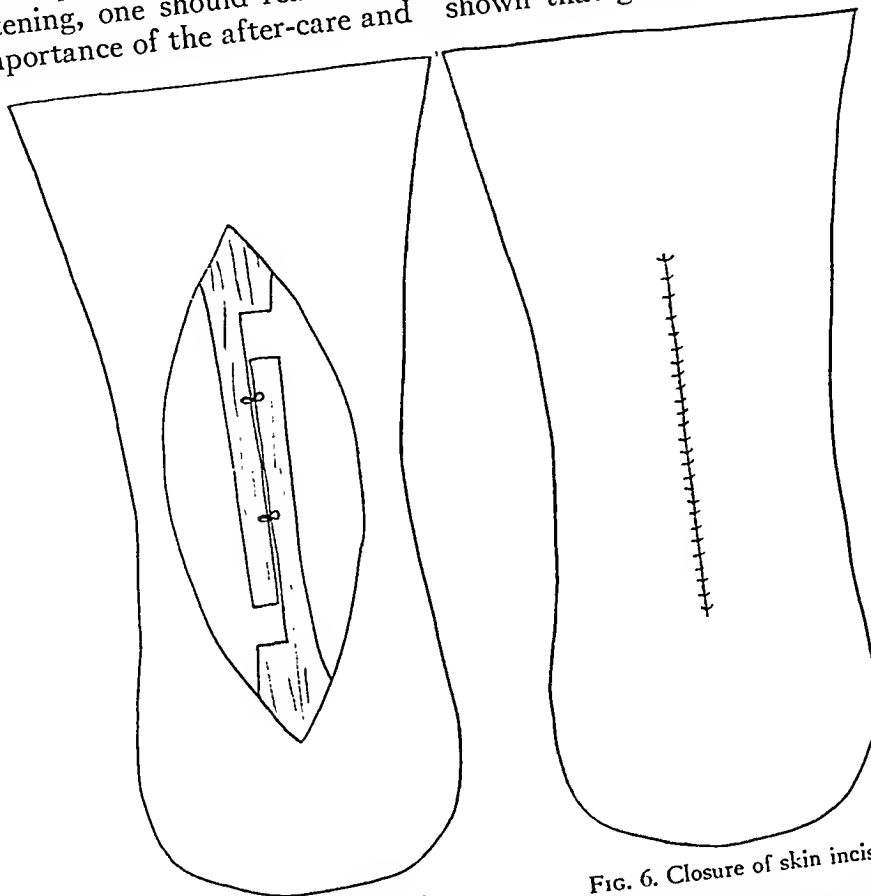


FIG. 5. Suturing the ends.

FIG. 6. Closure of skin incision.

treatment because of the danger of return of the deformity from contraction in ensuing scar tissue or from the persistence of the influences peculiar to the disease or deformity and its tendency to resume the primary malposition.

In cases of spastic paralysis of the extremities, where there is marked imbalance from the greater pull of one muscle group against another, combined with profound disturbance of muscle control, the best functional results can be obtained by weakening the stronger ones by means of tenotomies. Neurectomy has been tried and, in general, has been found wanting in its results. Furthermore, the loss of control from section of the motor nerves is permanent and as time passes, the opposing muscles may become overacting and cause deformity in the opposite direction, and in

times bring about marked improvement in these cases of imbalance, but if there is motor paralysis from neurectomy, there will still be less opportunity to secure balanced control in the muscle structures. The simplicity of subcutaneous tendon section as compared with the severance of nerves (which may require extensive and careful dissection) and the retention of power in the spastic muscles which may in many cases be brought under better control by systematic training, strongly recommends the procedure. Furthermore, if the first effort at restoring better balance by tenotomies is not successful, the operation can be readily repeated and by gradual stages, a more nearly normal balance of the muscles can be obtained. When this is secured, muscle training can be carried out more easily and with much better results.

# TECHNIQUE OF SECTION OF SOME OF THE SPECIAL TENDONS

In torticollis, one or both portions of the sternocleidomastoid muscle may be in-

fascia, the danger of such mishap is avoided. After withdrawal of the knife, the corrective tension is maintained and the index finger is used to tear through any

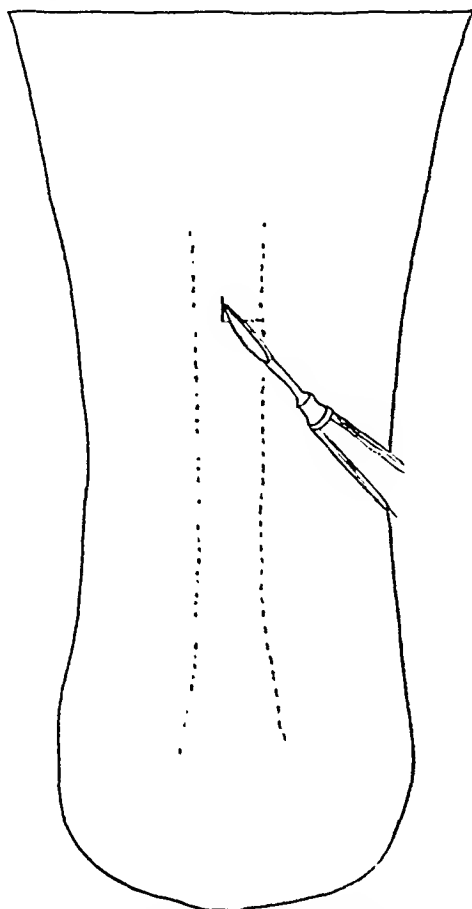


FIG. 7. Piercing the tendon at upper level and cutting off one-half.

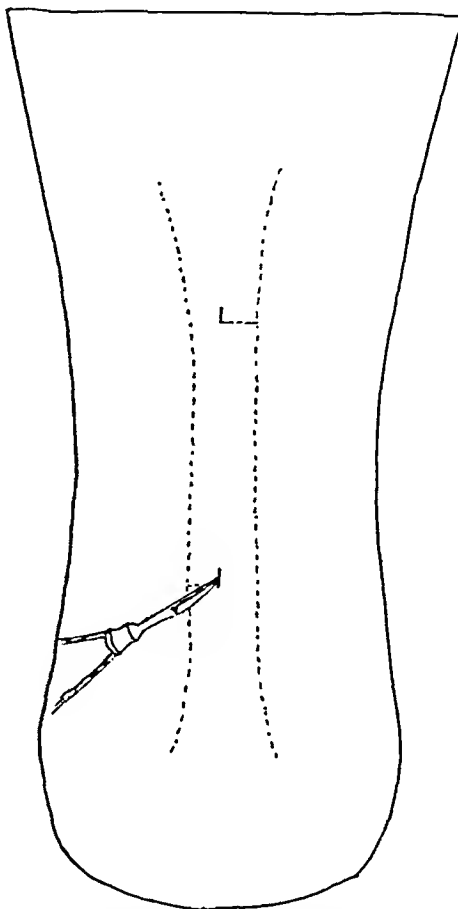


FIG. 8. Section of the other half at lower level.

involved, but the method of correction is the same for both conditions. The muscle is put in tension by pulling the arm downward and twisting the head so that the face turns to the affected side and the head to the opposite side. The tenotome is inserted near the posterior edge of the muscle and pushed forward along the upper border of the clavicle. The knife blade is then turned with the cutting edge against the tendon and the tissues are cut freely from the clavicle. The blade is pushed forward as the cutting proceeds, until the entire structure is severed. The fear of the operator is that he may injure the artery, vein or nerve that lie beneath, but if he will recall the thickness of the clavicle and that the muscle lies between the two layers of

remaining fibers and to push the posterior fascial plane off the clavicle. This requires considerable pressure by the finger end, but if it is persistently applied, a deep groove or sulcus will be felt along the top of and behind the clavicle and correction will be well accomplished.

In cutting the anterior and posterior muscles of the axilla, the arm should be abducted firmly and the tendon attachments to the humerus noted with the finger. The tenotome is then inserted either on the outer or under edge of the tendon and the tendon is freed from the humerus. Further stretching of the arm outward and upward will secure greater separation of the severed parts. This procedure is curative in some cases of recur-

rent dislocation of the shoulder as the head of the humerus may be dislocated downward when the arm is elevated by the

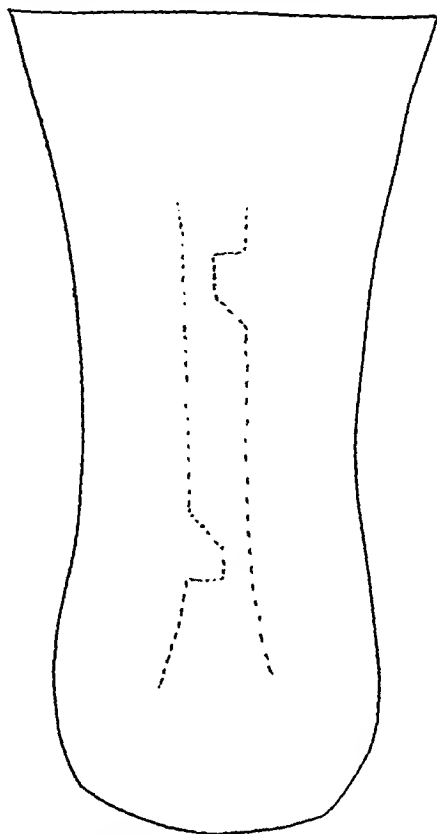


FIG. 9. Lengthening accomplished.

pull of the deltoid and supraspinati muscles (Allis). This procedure is also indicated in some cases of neglected birth palsy in which marked shortening of the pectorals, latissimus and teres muscles occurs.

In marked adduction of the thigh, muscle section is accomplished quite close to the pubis. The tenotome is inserted just over the tense fibers as the leg is strongly abducted. All structures close to the pelvis are severed and then further elongation is secured by kneading the muscles to break through any remaining fibers. By this procedure, there is no danger of injury to the neighboring artery, vein or nerve.

In section of the internal and external hamstrings, the leg should be flexed on the pelvis and the lower leg extended as far as possible. This causes the tendons to stand out prominently. If the knife is inserted along the outer side of the tendons and slight cuts are made, the tendons readily give way. The leg should then be extended completely at the knee and the entire leg forcibly flexed to a right angle with the pelvis. In rare cases it may be necessary to cut the semitendinosus tendon which runs through the center of the popliteal space, but as it is extremely tense and located directly under the skin, its section presents but little danger. These tendons are commonly affected in spastic paralysis and sometimes hinder the patient from walking on the foot-sole and heel. The condition may simulate shortening of the tendo Achillis. If this is present, it must be corrected before the heel tendon is cut. Where toes have become contracted from short shoes and stockings, section of the plantar flexors will allow them to be straightened. The outer toes are the ones most commonly involved, and these tendons can be readily severed if the assistant will hold the foot in dorsal flexion by pressure against the metatarsal heads, thus causing marked plantar flexion of the toes. A long shanked knife is then inserted just in front of the metatarsal joint of the little toe, the point of the toe lifted with the left hand and the plantar tendon easily cut. The knife is pushed further across and the fourth toe tendon severed, then the third toe cut and finally the second one, all through the one skin puncture. After this, a small piece of gauze is placed over the puncture and held in place by adhesive tape. The shoes and stockings are put on and the patient walks out with but a minimum of inconvenience and a maximum of relief.

# LESIONS OF THE EPIPHYSES

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**G**ROWTH phenomena are dependent on the undisturbed normal development of the epiphyses.

Knowledge of epiphyseal growth prior to Roentgen's discovery was entirely dependent upon anatomic maceration studies. However, shortly after the epoch-making work of Roentgen, Poland began his remarkable study of epiphyseal development from a radiologic standpoint.

In order to discuss disturbances or lesions of the epiphyses, one must appreciate several facts with reference to them:

1. The epiphyses appear at a definite period.

2. Ossification as a rule proceeds in an orderly manner within the particular epiphysis.

3. There are as a rule a definite number of epiphyses for each of the long bones.

4. Ossification between the epiphysis and the diaphysis occurs at a definite period, under normal conditions.

5. Endocrine disturbances either delay or accelerate ossification within the epiphyses. Premature ossification leads to dwarfism, and delayed ossification may lead to gigantism.

6. Knowledge of the foregoing facts aid one in suggesting the probability of certain endocrine disturbances.

7. Since premature ossification leads to retardation of growth of an extremity, it follows that injuries about the epiphyses should not be operated upon.

8. The x-ray cannot be used to make the diagnosis of fractures about the joints in the very young. The epiphyses may be fractured, but on account of their cartilaginous nature the fracture may be missed.

9. A thorough study and knowledge of the appearance of the various joints at all

ages from birth to adult life is essential if one would attempt to interpret lesions of the epiphyses. No important subject is so completely ignored by the average physician as the knowledge of the appearance of the epiphyses.

There is one term which I believe should be entirely deleted from medical nomenclature—that term is epiphyseal separation. This is a thought which many observers had even before the days of the x-ray: for example, Malgaigne, in 1859, stated: "I rank among fractures these lesions (epiphyseal separations) which some modern authors would consider as distinct from them." In 1866, Hastings Hamilton said that, "Epiphyseal separations we shall not hesitate to classify with fractures and to submit them to the same rules of nomenclature."

For some strange reason surgeons have spoken of epiphyseal separations, apparently considering the epiphysis as something quite apart and not truly united with the shaft. Even though osseous union is not present, the union is cartilaginous; if we continue to hold to the definition of the term fracture as a break in continuity of bone or cartilage, we must of necessity consider all solutions of continuity of or through cartilage as true fractures. It follows that all epiphyseal separations are in reality fractures. If there is any displacement it is truly a fracture with displacement just as a similar fracture through bone would be.

It has become axiomatic to state that we cannot interpret injuries to the epiphyses unless we know what the normal looks like and what evidences of displacement are present after injury. It also becomes increasingly important to realize that in

the extremely young, prior to the period of ossification, the clinical examination, the interpretation of loss of function, and the localization of pain are of greater importance than the x-ray, a point to which I have previously referred in a paper on "Clinical Examinations versus the X-ray in Children." Anyone who has occasion to observe a great many injuries in the very young, will know how often one sees no radiographic evidence of a fracture line about joints although the clinical evidence of fracture is definite.

I believe that many normal joints are interpreted as epiphyseal separations by those who are not fully conscious of the appearance of the normal. On the other hand, it is important not to accept the absence of x-ray findings as excluding fracture and diagnose a so-called contusion or sprain. Both of these diagnoses are made entirely too often and without justification. The term sprain might well be almost deleted from the nomenclature of surgical literature. Careful study of patients who are supposed to have sprains will prove that they have fractures. In order to confirm this statement, one has to examine his patients carefully, insist on having pictures in various planes, and depend largely on clinical diagnosis.

It is urgent for us to remember that the small bony prominences to which ligaments are attached have less tensile strength than the ligaments which are attached to them. Therefore the ligaments will not tear or be injured before the bony prominence is pulled away from the shaft. Observance of this important point will help us to get away from the superstition that a sprained ankle hurts more and longer than a fracture. The pain is doubtless due to the fact that the individual has had a fracture which was unrecognized.

There are certain fundamental facts which become a part of our visual consciousness with reference to the appearance of epiphyses, and these are of vital importance to patients who have injuries about joints.

We must realize the date at which the epiphyses appear. We must realize the progress of ossification, and that at times irregular ossification proceeds within the epiphyses—that the epiphysis does not unite with the diaphysis entirely at the same period. More important is the fact that the epiphysis bears a definite relationship to certain lines along the diaphysis.

The appearance of the epiphyses for the acromion process between the ages of 14 and 16 years offers abundant opportunity for considering a normally developing epiphysis as a fracture. The epiphysis for the olecranon process appears between the ages of 11 and 14 and all too often gives ample opportunity for errors in diagnosis. Patients are at times treated for fractures of the olecranon when there is nothing wrong with the joint.

When there has been an injury about the elbow, particularly if it affects the inner aspect, fracture through the epiphysis for the internal epicondyle offers an easy possibility of error.

One should not overlook the fact when looking at the x-ray picture of a child's hand, that the epiphysis for the first metacarpal is at the upper end just as the phalanges are, whereas the epiphyses of the other metacarpals are at the distal end. This particular fact has given rise to speculation and experimental investigation, particularly in the studies of comparative anatomy, as to whether the first metacarpal is not in reality a phalanx, whether in the evolutionary process the first metacarpal has not actually become a vestigial remnant or entirely disappeared.

In the lower extremities the epiphysis for the lesser trochanter, which does not appear until about the ninth or tenth year, sometimes appears like a scale-like fracture.

One of the most conspicuous illustrations of opportunity for error is the appearance of the tubercle of the tibia. This is not infrequently mistaken for Osgood-Schlatter's disease, and so treated. I remember a doctor who interpreted the normal downward outgrowth of the tubercle of the tibia

as a fracture and suggested to the family that it needed to be either screwed or nailed down. Fortunately the family called in a consultant who realized that the patient did not have an injury to the tubercle of the tibia but in reality had a dislocated semilunar cartilage. This was operated on and the patient had a good knee thereafter.

In the foot the epiphysis for the posterior of the os calcis also offers opportunity for errors in interpretation on the part of those who are not conscious of the normal appearance. Too much emphasis cannot be laid on the importance of studying the normal appearance before attempting to interpret the x-ray. X-ray pictures are of great value in children, but this is entirely dependent upon the interpretation of the findings.

The great value and protection afforded by the elastic epiphyses to the growing individual against fractures in certain locations has long been a source of interest and speculation to many of us. I am sure that everyone interested in the subject of fractures has noted that fractures of the clavicle in the very young occur more often than fractures of the head of the humerus, the elbow or the base of the radius. At a little later period supracondylar fractures occur more frequently than fractures at the base of the radius, and as we approach

adult life, fractures of the base of the radius with the same mechanism, occur more frequently than do supracondylar fractures.

The epiphyses apparently have greater elasticity and consequently act as cushions. When a child falls on his outstretched hand, the force is transmitted to the lower end of the humerus and a fracture just above the elbow results. At a later date when the epiphysis at the base of the radius has ossified, the same amount of hyperextension causes a fracture of the base of the radius, as the force is expended before it reaches the lower end of the humerus. This is purely speculative—an attempted explanation of the mechanism of fractures occurring in different locations when force is directed in the same direction in individuals of different ages.

#### SUMMARY

Disturbances of the epiphyses result from many causes other than trauma.

As much or more information can be obtained from the radiologic appearance of a joint as can be obtained from metabolism studies in certain endocrine disorders.

Skeletal disturbances characterize retardation phenomena such as are found in dyschondroplasia.

Much can be gained by studying the normal joint appearance before one attempts to treat epiphyseal lesions.





# BURSITIS

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**I**NFLAMMATION may develop in any of the constant or adventitious bursae of the body. (Fig. 1.) A laceration or abrasion of the skin serves as a portal of entry for pyogenic organisms which may reach the bursa and cause an acute infection. Any of the bursae, even the deeper ones, may become infected from a contiguous abscess or very rarely a hematogenous bursitis may be caused by blood borne bacteria. This inflammation may become chronic. A bursa may be contused or torn by direct or indirect injury resulting in an acute traumatic bursitis which may also become chronic. In addition, frequent or repeated traumata result in chronic irritation and sometimes chronic inflammation without any acute phase. Tuberculous infection of a bursa is usually found only when the bursa connects with or is in very close proximity to an infected joint. Only rarely is it found as a separate entity. The same is true of syphilitic infection. Metabolic disturbances, such as gout, as well as the endocrinopathies, toxic disorders, foci of infection, etc., have been held responsible for some cases of chronic bursitis. Their causal relationship is certainly not proved, although they may be aggravating factors. The condition is found, for the most part, in adults; it is slightly more frequent in the male than the female.

The pathologic picture depends upon the etiology and the stage of the process. In the acute pyogenic infections, the reaction is the same as that found in the inflammation of other serous cavities, i.e., extravasation of fluid and white cells into the layers of the bursal wall, followed by the outpouring of fluid into the sac. The fluid at first is usually serous, but later may become seropurulent or even purulent. As the process subsides, the wall is thickened with scar

tissue and often strands of fibrous tissue extend into the sac as pedunculated tags or even form a network and connect various parts of the bursa. In the acute traumatic bursitis, there is a tearing of the wall and an extravasation of serosanguineous fluid into the cavity. This later becomes replaced with fibrous tissue. In cases due to chronic trauma, there is a gradual thickening of the wall until sometimes the entire bursa becomes a greatly enlarged, fibrous mass with almost complete obliteration of the cavity.

The development of calcification in a chronically inflamed bursa is an interesting and important complication. Calcification is frequently found in old tuberculous processes which are fibrotic and without adequate blood supply. Calcification and even ossification frequently develop in a hemorrhagic area in an injured muscle. Calcification develops in a bursa when sufficient fibrosis exists, when the hydrogen ion concentration is ideal and when the blood supply is inadequate. With a normal calcium in the blood stream, there is no reason to believe that decalcification of neighboring bone is necessary. It has been shown that the lime salts found here correspond chemically to bone, but it does not follow that they are derived directly from the bone. Just as the calcification occurs when all the physical conditions are ideal, so it may disappear when the processes are reversed.

Pain results as a natural accompaniment of the inflammation. If there is a severe, acute inflammation, the patient shows a marked systemic reaction. In all cases, the pain is increased on motion and motion of the part may be restricted, not only because of the pain but also because of fibrosis. The pain is increased when the

bursa is palpated by the examiner or compressed or stretched by muscular effort of the patient. Not only is tenderness found

proper treatment, the patient should expect complete relief.

The treatment in the mild acute case is

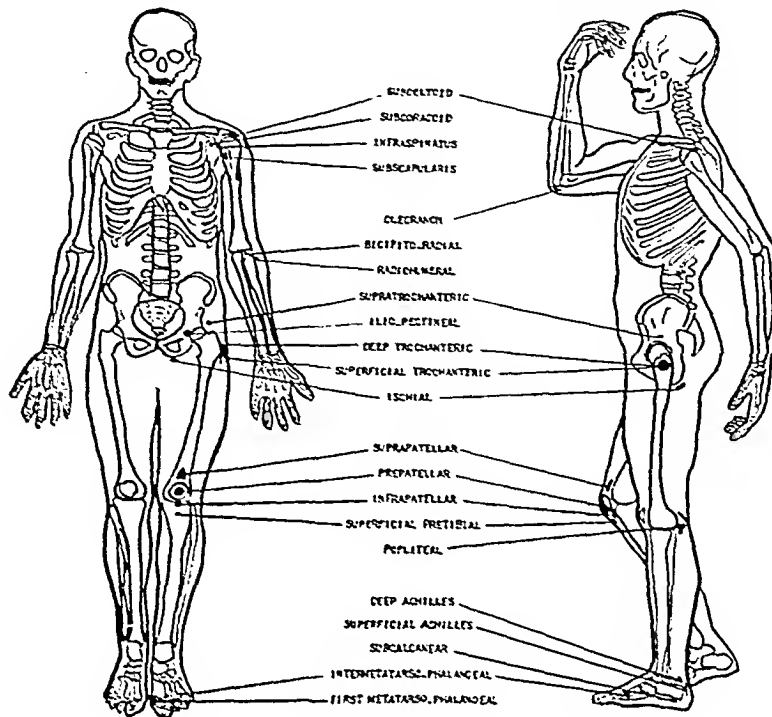


FIG. 1. Diagrammatic representation of the important bursae of the body.

on palpation but in the superficial bursae with any fluid and in the deep bursae with considerable fluid, fluctuation is noted. The x-ray shows calcification if it is present and often, even though there is no calcification, the distended bursa may be seen.

The diagnosis of bursitis can usually be definitely made; the term should not be used to describe indefinite and undiagnosed periarticular disorders. If the bursa is superficial, the diagnosis offers no difficulty. If calcification is found in the region where a bursa is known to exist, the diagnosis is usually certain. It must be remembered, however, that it is possible to have a chronic bursitis even though there is no calcification and sometimes calcification, which seems to be in a bursa, is actually in an adjacent tendon or fascial area. In some of the deeper bursae, diagnosis is made only on exploratory operation. Muscular and ligamentous sprains, acute and chronic tuberculous and non-tuberculous arthritis or synovitis, osteomyelitis, osteitis, periostitis, etc., must be differentiated. Under

rest and the use of heat or, very rarely, cold applications. If there is fluid in the bursa, aspiration, followed by a pressure bandage is necessary. Sometimes obliteration of the bursal sac can be accomplished by the injection of a sclerosing solution following aspiration. In more acute inflammation, especially when pus is present, the bursa should be widely incised. In the chronic cases, rest and heat, especially short wave radiation, will often relieve. In some special bursae, relief has been reported by rupture of the bursa and bursal pain has been relieved by x-ray radiation. The calcium in a bursa usually disappears in time with or without treatment, although the use of short wave is thought to hasten its absorption. Sometimes, when there is severe pain because of acute distention of the bursa due to a calcified mass, incision and curettage, injection of novocaine, or irrigation with saline may be used. In some cases, where the pain persists in spite of more conservative treatment, it may be necessary to excise the bursa. Bursae, especially the

subcutaneous ones, should not be excised indiscriminately, however, as they often act as essential pads or lubricating sacs.

#### SPECIAL TYPES OF BURSTITIS

*Subdeltoid or Subacromial.* This is the largest bursa about the shoulder. Not only is it involved more frequently than any other bursa here, but also its involvement is the most common cause of shoulder disability. According to Haggart and Allen,<sup>1</sup> 79½ per cent of 300 cases of painful shoulder were due to "pathology in or related to the subacromial bursa and tendons of the short rotator muscles." This bursa is a multilocular sac and often made up of connecting, but sometimes distinct, subacromial and subdeltoid portions. It very seldom communicates with the shoulder joint. Involvement of this bursa may be either acute or chronic.

The *acute traumatic type* may be due to direct or indirect trauma; that is, it may be a contusion or laceration, or it may be associated with injury of the supraspinatus tendon, acromion or shoulder joint. There is usually no history of previous disease. There is severe pain in the shoulder which is increased on abduction and external rotation, especially when these motions are resisted; abduction and external rotation are also markedly limited. If there is a rupture of the supraspinatus tendon or other serious injury, this must be repaired. If it is thought that the bursa alone is damaged, immobilization and use of heat for a week or ten days followed by careful massage and manipulation are used.

The *acute bursitis with calcification* presents a somewhat similar picture, except that the symptoms are usually more severe. The usual history is that the patient underwent a prolonged or unusual exertion, or that he jerked his arm and felt or heard a snap in his shoulder. The shoulder remained somewhat painful, but not unbearably so. During the night that followed, or possibly within the next day or two, he was seized with a sudden and unbearable pain in his shoulder. Sleep was impossible

and when the patient presents himself to the physician he is suffering exquisite pain and is most fearful that the examiner will touch or move his shoulder. The joint may appear somewhat swollen. The patient may be willing to demonstrate a little active flexion and extension, but absolutely no abduction. Passive motion is somewhat more extensive than active, but there is usually little or no abduction; if this motion is present, pain will be felt when the bursa slides beneath the acromion. Palpation demonstrates marked and well-localized tenderness over a point immediately lateral to the tip of the acromion. The x-ray shows the area of calcification in the floor of the bursa or in the tendon of the supraspinatus.

Many methods are used in the treatment of this condition. In our experience, rest and short wave therapy relieve a large percentage. Usually, the patient need not be hospitalized, but the arm should be placed in a sling with a pad in the axilla. A single short wave treatment of forty-five to fifty minutes is given at once, or, if the patient is in the hospital, two thirty to forty minute treatments are used. The next day the patient usually reports the best night since the onset of his trouble. If the patient does not get relief after a few treatments, irrigation with saline as advised by Patterson and Darrach<sup>2</sup> may be done. Some advise cold packs instead of heat for the first few days. Codman<sup>3</sup> suggests incision under novocaine and expulsion of the calcareous material. Ferguson<sup>4</sup> advises injection of novocaine and Lattman and Merritt<sup>5</sup> use x-ray radiation. The physician will use the treatment with which he has had the most experience and with which he gets the best results.

The patient is allowed to keep the arm in a sling for a few days. Usually within less than one week the pain will have lessened and the patient is encouraged to spend as much time as he can during the day with the arm slightly abducted, perhaps resting on a pillow or arm of a chair. Careful examination will demonstrate whether muscular

rigidity is developing. If it is not, no passive movements are carried out during the first week, lest the bursitis be aggravated. If the muscles seem to be getting spastic, abduction must be secured by means of a splint in order to prevent the shoulder from becoming fixed in adduction. As soon as the pain subsides, careful massage and mobilization are carried out, the area directly over the bursa being avoided in the massage. The more radical procedures are not necessary in the usual case. As a rule, the calcification disappears and so there need be no concern about leaving it as a permanent cause of irritation. Those who advocate immediate irrigation with saline state that they are saving the patient several days of disability, but the average patient would rather have a few more days of disability than be subjected to irrigation, especially by inexperienced hands.

*Chronic adhesive bursitis or periarthritis* of the shoulder is a frequent sequela of improperly treated acute cases, or may occur as a gradual and insidious process. If the shoulder has not been properly mobilized, adhesions develop both within the bursa and in the muscular and periarticular structures. The patient complains of a more or less constant pain in the shoulder, but he is bothered especially by the lameness or inability to use the arm normally, as in combing the hair, dressing, etc. Examination discloses marked limitation of motion. In these cases, it is desirable to give intensive heat, massage, passive motion and manipulation. Often the range of motion can be increased by these means so that the patient is satisfied. If it cannot be, careful manipulation under anesthesia is desirable. This should be followed by a few days of immobilization in the abducted position and then intensive heat, massage and active and passive movements.

In the *chronic bursitis with calcification*, the symptoms are much the same, except that there may be less restriction of motion, but more pain when the arm reaches the horizontal position. There is localized tenderness and the x-ray shows the calcifi-

cation. (Fig. 2.) Prolonged short wave treatments with massage and active and passive motion are usually effective. Oper-



FIG. 2. Calcification in the subdeltoid bursa of a woman of 36 years. Pain and disability have been present for two years. Abduction is limited to 135 degrees. Two irrigations, the last under fluoroscopic control, failed to remove the calcification. The mass was penetrated by the needles with considerable difficulty and some fibrous tissue and calcified material were washed out. A prolonged course of inductotherm treatments with massage and manipulation is regarded as the best treatment and is being used.

ative removal of the calcified deposit is not advisable in the usual case as the deposit is not necessarily the cause of the pain and is removed with the greatest difficulty when it is in the supraspinatus tendon. Sometimes the pain and disability are worse following operation. If necessary, anesthesia and manipulation, as described above, may be used.

*Subscapularis.* This bursa, which lies between the tendon of the subscapularis muscle and the anterior aspect of the capsule of the shoulder joint, may become inflamed. Active and passive motion of the shoulder are limited and painful, resisted adduction and internal rotation especially causing pain. Crepitus may be felt. Tenderness over the subcoracoid region is found and sometimes calcification is visible in the x-ray. If calcification or thickening of the bursa is present, it may be desirable to

excise it; rest and heat should be given a good trial first, however.

*Infraspinatus.* The small bursa under the tendon of the infraspinatus is sometimes the seat of an inflammation. Usually, however, it is found involved secondarily to disease of the shoulder as it often communicates with this joint.

*Coracoclavicular or Subcoracoid.* Involvement of this bursa closely resembles disease of the shoulder joint and sometimes exploration is necessary to confirm the diagnosis. If chronic inflammatory thickening of the bursa or calcification is found, excision is desirable.

*Olecranon (Miner's Elbow).* This is a superficial subcutaneous bursa which may become infected and acutely inflamed by open laceration or extension from a cellulitis. An acute traumatic bursitis can be set up by a contusion over the olecranon, which is especially likely to occur in a bursa already chronically inflamed. Repeated minor traumata of the bursa may cause an irritation here and a chronic inflammatory process.

The *acutely inflamed bursa* shows the typical inflammatory reaction of the wall and an outpouring of serous, seropurulent or even purulent material into the sac. The patient notices a fluctuant swelling and pain, the intensity of which depends upon the degree of inflammation. Reddening of the skin and an increase in surface temperature are found if infection is present. In the differential diagnosis, cellulitis without involvement of the bursa, osteomyelitis, etc., must be differentiated. Wide incision of the skin, subcutaneous tissues and bursa is necessary.

The *chronic* case shows the typical inflammatory reaction with a variable thickening of the wall and the fibrous network within the sac. There may be little or no pain even though acute trauma has caused an extravasation of fluid. Some tenderness, but no increase in surface temperature is found; if fluid is present, there is fluctuation. Calcification is very seldom present. Sprain-fracture of the

olecranon, osteomyelitis, osteitis, periostitis, etc., must be differentiated. Fluid should be aspirated, if it is present, and a pressure bandage applied. It may be necessary to repeat the aspiration, or, if desired, aspiration may be followed by the injection of 2 or 3 c.c. of a 5 per cent solution of sodium morrhuate or the same amount of a 5 per cent solution of quinine and urea hydrochloride. Before injecting a sclerosing solution, one must be certain that the bursa does not communicate with the elbow joint, but this condition is found very rarely. Excision of the chronically inflamed bursa which does not respond to other treatment can be easily performed, but it should not be done without due consideration, as this bursa acts as a very efficient protector of the olecranon.

*Bicipitoradial.* Pain and tenderness about the tendon of the biceps brachii just short of its insertion may be due to inflammation of the bursa beneath the tendon. Sprain of the tendon or a tenosynovitis give similar symptoms, but usually the tenderness of bursitis is quite localized and seems to be behind the tendon. Tenderness in sprain of the tendon is found somewhat more distally and usually is more diffuse, while tenosynovitis shows crepitus, more widespread tenderness and perhaps swelling. In all these conditions, pain is increased when the elbow is flexed against resistance. The bursitis may be precipitated by prolonged or unusual use of the biceps, as the resumption of bowling in the fall. Time, rest and heat will usually relieve; rarely is it necessary to excise the bursa.

*Radiohumeral.* There is a condition frequently seen in which pain is present over the lateral epicondyle of the humerus with radiation down the dorsum of the forearm and an associated weakness of the grip when the forearm is pronated and the wrist flexed. This condition is usually referred to as "tennis elbow." In 1922 Osgood<sup>6</sup> reported his personal case of this condition in which it had been found that the disorder was due to an inflammation of a bursa beneath the conjoined tendon of

the extensors of the wrist. He concluded that most cases of "tennis elbow" are due to this bursitis; this explanation is generally accepted in this country, but less generally abroad.

In 1936 Cyriax<sup>7</sup> reported a series of cases in which he reviewed the possible causes of this condition. He concluded that a great majority of the cases were due to a periostitis, secondary to tears of the tendinous origin of the extensor carpi ulnaris. He stated that, in his experience, bursitis did not account for more than 1 or 2 per cent of the cases. He also mentioned that synovitis or arthritis of the radiohumeral joint, adhesions, gout, neuritis and tears of the capsule, ligaments or muscles, etc., had been variously blamed for the condition.

Repeated pronation and supination of the forearm or continuous or unusual exertion with the forearm pronated often cause this disorder. This latter position is used by tennis players in their backhand stroke, by carpenters in their use of the saw or hammer, and by plasterers when working on a ceiling, by fishermen in fly casting, etc. The diagnosis of "tennis elbow" is easily made by finding tenderness over the upper forearm immediately distal to the lateral epicondyle and an increase in the pain here when the patient completely flexes his fingers with the forearm pronated and the wrist already flexed. To determine whether or not the disability is due to a bursitis is very difficult. Usually, exploratory operation fails to reveal the presence of a bursitis.

In general, the treatment will be the same, no matter what the cause of the disability. Time and rest will bring relief in the course of several months. Hannson and Horwick<sup>8</sup> advise that the forearm be immobilized on a cock-up splint and that heat and massage be applied. Cross-hatching with many layers of adhesive will sometimes relieve. Carp<sup>9</sup> states that he cured four out of eight patients by rupture of the bursa under digital pressure. Alcohol and novocaine injections, operative resection of the muscles as they arise from the epi-

condyle or removal of the synovial fringes of the radiohumeral joint have also been recommended. Cyriax, who champions the theory that a great majority of these cases are due to incomplete periosteal tears, states that "tennis elbow" responds to manipulation without anesthesia. Cases which do not respond to these conservative measures should be operated upon, the tendon sectioned and the bursa removed.

*Iliopsoas or Iliopectineal.* Involvement of this bursa is much more prevalent than is commonly thought, since Connor<sup>10</sup> in 1933 presented thirty-three cases of his own, stating that only thirty-seven cases had been reported previously. The bursa is a constant one and is located between the tendon of the iliopsoas and the iliofemoral ligament. It connects with the hip joint in 15 per cent of the cases. The bursa is injured when a strain is placed upon the iliopsoas muscle, as in violent hyperextension of the hip, or when the iliopsoas is suddenly contracted. Pain, which may be referred to the knee, is found if the bursa is involved. Examination reveals weakness of the extremity, tenderness immediately over the bursa, and swelling if there is sufficient fluid present. (Finger<sup>11</sup> reported a case which yielded 210 c.c. of fluid on aspiration.) Pain on motion, especially adduction, extension and internal rotation, is usually present. The hip may be held in abduction, flexion and external rotation.

Inguinal or femoral hernia, abscess from tuberculosis of the spine or hip, swollen lymph glands, dilatation of the femoral vein or artery, or neoplasm also may cause swelling here. Many other conditions, such as kidney stone, arthritis of the hip, etc., may cause pain in this region without swelling. In tuberculous disease of the hip joint, the bursa is involved when it communicates with the joint. Rest and heat relieve the usual case; if not, traction or a plaster cast should be used. Aspiration is desirable if there is embarrassing fluid present; excision of the bursa may be necessary. It is important to realize the possibility of

disease of this bursa. O'Connor reports a case which was at first thought to be hip disease. Incision was made through both



FIG. 3. Calcification in the supratrochanteric bursa of a man of 33 years. He demonstrated tenderness in the gluteal and supratrochanteric regions following a fall. X-rays taken immediately revealed the calcified masses. After thirty inductotherm treatments over a three month period, x-rays were repeated and showed that the calcification had entirely disappeared.

bursae and hip, so that the hip joint, which was free of disease, was contaminated and caused to ankylose.

**Deep Trochanteric.** This bursa is constantly found between the greater trochanter and the tendon of the gluteus maximus. Its inflammation is usually subacute or chronic and not associated with the accumulation of fluid. Pain and tenderness are found over the greater trochanter, the pain being increased on resisted external rotation. Pyogenic infection of the bursa with considerable purulent exudate may be found. In this case, the fluid will extend under the gluteus maximus, obliterating the depression immediately back of the trochanter and some gluteal pain and even sciatic radiation may result. Calcification of the bursa may be demonstrated in some cases by x-ray.

Arthritis of the hip, sacroiliac joint or even lower lumbar spine, osteomyelitis of the femur, etc., may cause pain in the region of the trochanter and must be differentiated. We have seen several cases of Marie-Strümpell arthritis whose first symptom was pain over one or both trochanters. The important diagnostic point is pain on resisted internal but not external rotation. There is also tenderness directly over the trochanter. Rest and heat usually relieve the chronic forms, although excision may be necessary, especially when there is extensive calcification. Wide incision should be made in the acute pyogenic infections.

**Superficial Trochanteric.** An adventitious bursa may develop between the skin and the greater trochanter in those whose hips are subject to chronic occupational trauma. It is involved less frequently than the deep bursa. Usually the symptoms are less severe and the tenderness more superficial. The same treatment is used as is used in the deep trochanteric bursitis.

**Supratrochanteric.** There are several inconstant bursae about the tendinous insertion of the gluteus medius which may become inflamed. Goldenberg and Leventhal<sup>12</sup> reported  $5\frac{1}{10}$  per cent of 515 routine hip x-rays of patients between 15 and 69 years showed supratrochanteric calcification. The patient complains of pain in the hip, which may be increased on abduction, but usually the diagnosis depends upon the finding of calcification by x-ray. (Fig. 3.) Rest and short wave heating and massage usually completely relieve, and operative removal is seldom indicated.

**Ischial or Ischiogluteal (Weaver's Bottom).** This is a superficial and subcutaneous bursa which may develop over the ischial tuberosity in those whose occupation causes them to spend considerable time sitting on a hard surface. In cases where there is a bursitis, a tender, fluctuant swelling is found. The diagnosis offers no difficulty. Aspiration, or rarely excision, may be necessary.

**Popliteal.** Cystic swelling in the popliteal region is frequently found and there



are several constant and other inconstant bursae here which may be responsible for these swellings. In 1877 Morant Baker<sup>13</sup> reported eight cases of popliteal swelling which he regarded as cysts, the majority of which communicated with the knee joint. Haggart,<sup>14</sup> in April, 1938, reported operations during the preceding four years upon twelve patients with popliteal swelling and stated that nine of these were herniations of the knee joint, one was a bursitis of the semimembranosus bursa, one was a lipoma, and the last a diffuse hypertrophy of the subcutaneous fat pad. In October of 1938, Wilson, Eyre-Brook and Francis<sup>15</sup> reported that between 1928 and 1938, twenty-one cases of popliteal cyst were operated upon at the Hospital for the Ruptured and Crippled. In fifteen cases, a cyst was found which communicated with the knee joint, and it was their opinion that these cysts were actually distensions of the gastrocnemius bursa. It is a question, then, whether these popliteal swellings are herniations of the joint or bursae, as their structure is identical and their communication with the knee joint very inconstant and incomplete.

There are several bursae in this region. A constant one (anserina) is found over the tibial collateral ligament and beneath the tendons of the gracilis, semitendinosus and sartorius. Another is found beneath the tendon of the semimembranosus and the collateral ligament of the tibia and another between the medial head of the gastrocnemius and the capsule over the inner condyle of the femur. Sometimes one is found between the semimembranosus and medial head of the gastrocnemius. These latter two often communicate.

Involvement of a popliteal bursa may occur at any age and trauma is the usual cause of the disorder. Pain is an early symptom and may precede the finding of visible swelling. In many cases, painless swelling is the only complaint, the swelling being most prominent when the knee is extended. Usually, even though the sac does not connect with the knee joint, there

is pain in and restriction of motion of the joint and signs suggesting internal derangement. It may be impossible to say whether the swelling is a cyst or a bursa, but it should be determined whether or not it communicates with the knee joint. In some cases, there is a very definite communication and the interchange of fluid can easily be demonstrated by exerting pressure over either the patella or the swelling. In other cases, an x-ray after air injection is necessary to differentiate.

Small bursae with mild symptoms may be ignored and may disappear spontaneously. In some instances, aspiration may be desirable. In cases where swelling persists and is sufficient to interfere with joint function, complete excision is necessary.

*Prepatellar (Housemaid's Knee).* This is one of the large, subcutaneous bursae which often becomes inflamed in those who kneel a great deal, or who receive frequent contusions on the anterior aspect of the knee. Also, it may become acutely inflamed because of infection by a pyogenic organism through an abrasion or laceration of the skin. This will cause an acute inflammatory reaction of the bursal wall with the development of a seropurulent or purulent exudate in the bursa. In most cases, there is a gradual thickening of the wall due to constant trauma, and then, after an unusually severe trauma or other cause, there is a marked outpouring of serous fluid. This may amount to as much as 100 c.c. In other cases, the thickening of the bursal wall may continue and concentric rings of fibrous tissue be laid down, so that it is several centimeters thick and the lumen is all but obliterated. The diagnosis of this condition offers no difficulty because of the superficial nature of the bursa. The treatment in the acute purulent case is wide incision and drainage. Usually two lateral incisions are made in order to avoid a scar on the anterior surface. In the acute exacerbations with accumulation of fluid, it is necessary to aspirate and apply a pressure bandage.

This may be repeated several times if necessary. A sclerosing solution may be injected following aspiration in cases which



FIG. 4. Calcification in the suprapatellar bursa of a 38 year old man with chronic, long-standing pulmonary tuberculosis. The suprapatellar region was swollen and tender, but these symptoms lasted but a few months. The bursa was not explored.

tend to refill. Carp<sup>16</sup> uses 2 to 3 c.c. of 3½ per cent iodine. Five per cent sodium morrhuate, 5 per cent quinine and urea hydrochloride, or 3 per cent carbolic acid may be used if preferred. Excision of the bursa is seldom justified as it removes a very necessary protective cushion from the anterior surface of the patella and only in very chronic cases where there is marked inflammation and thickening of the wall should this be done.

*Suprapatellar or Quadriceps.* This bursa lies between the quadriceps tendon and the lower end of the femur. According to Spalteholz, it communicates with the knee joint in 85 per cent of the cases. It is possible to determine whether this communication exists by exerting pressure over either the patella or the bursa and noting whether there is an increase in fluid in the other region. It is obvious that, when there is a communication with the

knee joint, involvement of one means involvement of the other and the treatment will be directed toward relieving the primary disorder.

Sometimes, inflammation may develop in a bursa which does not communicate with the knee joint. In this case, a painful, fluctuant swelling develops above the knee and is especially evident under and on either side of the quadriceps tendon. Calcification may be demonstrated by x-ray. (Fig. 4.) In the usual case, aspiration followed by rest and heat will relieve. Repeated aspiration may be necessary. A case of tuberculous infection of the bursa without involvement of the knee was reported by Stewart.<sup>17</sup>

*Deep Pretibial or Infrapatellar.* This is a constant bursa found between the patellar ligament and the anterior surface of the tibia, not communicating with the knee joint. It is frequently involved. Pain immediately below the knee is found and inspection may show that the usual depressions on either side of the ligament are filled out. In addition, there will be an increase in the pain here on resisted extension and tenderness on palpation. Synovitis, arthritis, disorders of the patellar fat pad and other internal derangements of the knee must be differentiated. Rest and heat will usually relieve. A posterior splint may be used to immobilize the knee, yet allow the patient to remain ambulatory. Aspiration may be indicated and possibly the injection of a sclerosing solution. Excision is seldom justified.

*Superficial Pretibial.* This bursa is sometimes found under the skin, superficial to the tibial tendon at its attachment to the tuberosity. The diagnosis is made by finding a tender, fluctuant swelling here. Rest and heat usually relieve; if not, aspiration or, rarely, excision is necessary.

*Retrocalcaneal or Deep Achilles (Albert's Disease).* Painful heel or achillodynia may be caused by inflammation of the bursa which lies between the tendo Achillis and the calcaneus. Trauma is the usual cause of the involvement and pain and

swelling may be the patient's complaints. The pain is increased when the tendon is made to contract against resistance and tenderness is elicited at either side of the tendon, immediately short of its insertion.

There are many other causes of achillob-dynia, which must be differentiated. Teno-synovitis usually shows swelling, diffuse tenderness and perhaps a silky crepitus along the course of the tendon. Sprain of the tendon shows more localized tenderness over the point of insertion. Apophysitis of the os calcis, which is found only in the first two decades of life, and periositis are both demonstrable by x-ray and usually cause more widespread tenderness.

In the average case, relief may be gotten by the application of a felt pad under the heel and an extensive adhesive plaster strapping which relieves the tension on the tendon. The stiff counter of the heel should be removed. A few days' complete rest is justified if ambulatory treatment does not relieve, and in rare cases excision may be necessary.

*Superficial Calcaneal or Posterior Achilles.* A subcutaneous bursa may develop over the most prominent posterior aspect of the calcaneus. It is generally due to unusual pressure, as from a stiff counter on the shoe. The diagnosis is not difficult, as a superficial, tender, fluctuant swelling covered by a calloused area develops. The condition is easily relieved by removing the stiff counter of the shoe. The painful callous should be treated by the application of 10 per cent salicylic acid ointment. The bursa should not be excised, as it acts as a natural cushion for the calcaneus.

*Subcalcaneal.* There is usually a bursa under the tuberosity of the calcaneus at the point of greatest weight bearing. There may be additional bursae over the anterior, as well as midcalcaneal areas. Acute or chronic trauma is usually responsible for their irritation. Sharp local pain with radiation into the leg is found. Foot strain, calcaneal spurs, etc., must be differentiated. Rest and hot applications relieve the acute cases. A steel support with

a cupped heel or a ledge which removes the weight from the tender area should be used in the chronic cases. If this does not relieve, excision may be necessary. Hertzler<sup>18</sup> is of the opinion that surgical excision followed by packing of the wound with gauze saturated with a 3 per cent iodine solution is the best treatment for the chronic cases.

*First Metatarsophalangeal.* An adventitious bursa may develop over the mesial aspect of the first metatarsophalangeal joint in cases of hallux valgus. The diagnosis of "bunion" is readily made by the patient. Excision of the bursa without osteotomy for correction of the hallux valgus is seldom justified. Properly performed operation for correction of the bony deformity relieves the bursitis. In the acutely inflamed bursa, complete rest and relief of pressure are necessary and an ointment containing opium or other anodyne may be used. In some chronic cases where osteotomy is not indicated, temporary relief may be gotten by alteration of the shoe or by a splint or protector.

*Intermetatarsophalangeal.* There are four bursae between the metatarsal heads. If one or more of them becomes inflamed, a severe metatarsalgia results, although metatarsalgia is not usually caused by a bursitis. In rare cases, there may be sufficient fluid in the bursa to cause a tender, fluctuant swelling. If this is found, the bursa should be excised. Most cases of metatarsalgia, whether they are due to a bursitis or not, are relieved by a shoe of proper width, with an added metatarsal pad or bar. Exercises and hot soaks for the feet should also be used. In cases where conservative treatment does not relieve, and in those in which it is thought that there is a bursitis present, the painful area may be excised and curetted, thus obliterating the bursa.

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THE calories in a lump of sugar will supply the brain with enough calories for a day of thought. This is true, however, only of the free and easy mind. Worry and nervous strain waste energy by increasing the muscular tension during the day and disturbing the sound sleep during the night.

The brief excerpts in this issue are taken from "Sensible Dieting" by William Engel (Knopf).

# THE PLACE OF THE BIOPSY IN THE DIAGNOSIS AND TREATMENT OF TUMORS AND TUMOR-LIKE LESIONS OF THE EXTREMITIES

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**E**ACH year one cannot help but be impressed by the steady progress of medicine in its attempts at solving many of the major problems with which it is confronted. At the same time more and more one is forced to the realization of the limitations of the individual in keeping up with this progress, even in his chosen field. As a result, the clinician has come to rely with ever greater frequency upon the pathologist for his opinion, both in respect to diagnosis and treatment, for the pathologist as a rule is in a peculiarly strategic position, depending as he does upon factual evidence obtained by examination of tissues or the various products of body metabolism.

Time was, and not so many years ago, when the pathologist was considered scarcely more than a glorified technician, relegated to the darkest corner of the hospital basement, where he was permitted to carry on his ghoulish investigations as best he might with the most inadequate facilities conceivable. Gradually he has emerged from his comparative obscurity to a position of relative importance in the organization of hospital medicine. And the time will come perhaps when he actually is recognized professionally as a physician and consultant along with the surgeon and internist, and may hope to share commensurately with them for services rendered. It *must* come, or else medicine will slip backwards, if good, honest, capable men cannot be attracted to the field of pathology for lack of an adequate living to be derived therefrom. In the last analysis, it is chiefly in the experimental laboratory that those studies can be made which

carry medicine ever on and upward toward that ultimate goal, the control of all disease, whether it be pestilential, metabolic or neoplastic in nature.

It is with this point of view in mind, the desire to play a real part in contributing to the welfare of the patient, that the pathologist assumes his share of the responsibility in arriving at a diagnosis and in recommending any particular form of therapy. With the enormous strides which have been made in the past decade or so in the refinements of laboratory diagnosis, it is obvious that the busy surgeon or physician cannot be his own pathologist as was more or less true in the "horse and buggy" days only a comparatively few years ago. It is no longer sufficient merely to say, "this is a malignant tumor; it should be removed surgically." Too many ill-advised and unnecessary operations have been performed; too many lives sacrificed by the surgeon, from lack of adequate study of the case and too hasty decision, without the benefit of modern laboratory facilities and without consultation with his confrère, the pathologist. Only rarely does one encounter such men as Bloodgood, Hertzler, Graham, or Babcock, skillful surgeons and experienced tissue pathologists combined.

Nowhere does this need of coöperation show itself more fully than in the situation which exists in respect to the surgeon, the pathologist and the radiologist. They are mutually dependent upon each other in determining the proper course to follow in any given case. The old axiom, "two heads are better than one," can scarcely better be exemplified than in this relationship in

## Smith—Biopsy

the care of patients suffering from neoplastic or suspected neoplastic disease. Gradation of malignant processes, confirmation of the clinical diagnosis, integra-

other examples where misguided enthusiasm is possible if surgery is generally employed as the method of choice in treatment. On the other hand, the early

	Benign	Malignant
I. Tumors of epithelial cell origin	1. Papilloma	1. Basal cell "carcinoma" (usually benign clinically)
(a) Pavement cell type.....		2. Squamous cell carcinoma
(b) Glandular type.....	1. Sweat gland adenoma	1. Adenocarcinoma
	2. Sebaceous gland adenoma	2. Adenocarcinoma
II. Tumors of connective tissue origin.....	1. Fibroma	1. Fibrosarcoma (including periosteal fibrosarcoma)
	2. Lipoma	2. Liposarcoma
	3. Myxoma (rare)	3. Myxosarcoma
	4. Chondroma	4. Chondrosarcoma } osteogenic sarcoma
	5. Osteoma	5. Osteosarcoma
	6. Benign "giant cell" tumor of bone	
III. Tumors of hematopoietic and reticulo-endothelial system origin.....	1. Lymphoma	1. Lymphosarcoma
		2. Lymphoid leukemia
		3. Hodgkin's disease
		4. Boeck's sarcoid
		5. Myeloid leukemia
		6. Plasma cell myeloma (multiple myeloma)
		7. Endothelial myeloma (Ewing's tumor)
		8. Erythroblastosis
IV. Tumors of muscle cell origin.....	1. Leiomyoma (smooth muscle)	1. Leiomyosarcoma
		2. Rhabdomyosarcoma (striated muscle)
V. Tumors of pigment cell origin.....	1. Nevus (melanoma)	1. Malignant melanoma
VI. Tumors of nervous system origin.....	1. Neurofibroma	
	Recklinghausen's disease	
	2. Neurinoma	1. Neurogenic sarcoma
	1. Hemangioma	1. Angiosarcoma (Kaposi's disease)
	(a) Capillary	
	(b) Cavernous	
VII. Tumors of endothelial cell origin.....	2. Lymphangioma	2. Synovioma
	3. Glomus tumor	

tion of the roentgenologic, clinical and pathologic findings are all vitally important to the patient and surgeon alike in deciding how any given case should be handled. If metastasis of an osteogenic sarcoma to the lungs has already occurred there would seem to be very little point in subjecting a patient to the trauma and shock of radical surgery by amputation. Giant cell tumors and Ewing's tumors are

amputation of an extremity with an osteogenic sarcoma offers a nearly 20 per cent chance of cure, and is the only possible effective method of therapy. But immediate frozen section biopsy diagnosis by the pathologist at the time of operation in doubtful cases may save a leg which is the site of an atypical and confusing osteitis, osteomyelitis or even a xanthomatosis of the Hand-Christian-Schüller type.

Conservatism in surgery is again something to be deplored, when surgery is indicated. No surgeon wants to do a high amputation for a gangrene of the great toe. Yet from bitter experience he has learned that if the lesion is that of thromboangiitis obliterans, it will only be a question of time until he is confronted with the necessity of such a procedure, if he has contented himself by conservatively amputating the foot alone. Similarly in osteogenic sarcoma, there is no way of telling even by roentgenogram just how far along the medullary canal the tumor has extended, and the more radical the surgery, the higher creep the figures of recovery. But surely the surgeon is entitled to the moral support and sharing of responsibility by the pathologist before urging such a radical operative measure.

With these introductory comments regarding the place of the pathologist in the modern practice of medicine, let us turn to a consideration of the various tumors and tumor-like lesions of the extremities from the standpoint of pathologic diagnosis, particularly in its relationship to treatment. At first thought, one might dismiss the subject briefly with a discussion of the various bone tumors. As one reviews the field more carefully, however, one is confronted with what amounts to an encyclopedic presentation of oncology, for actually, with the exception of brain tumors, almost every other recognized type of tumor, either as a primary or a metastatic lesion, may be encountered in the extremities. The brief list on p. 294 gives in outline form the various primary neoplasms which do occur with varying degrees of frequency.

For convenience, the various tumors of bone are reassembled from the above classification and presented as a separate entity, making up as they do the largest and most important group of neoplasms of the extremities:

- I. Benign tumors of bone
  1. Osteoma
  2. Chondroma

3. Benign giant cell tumor (usually clinically benign, but subject to subsequent malignant transformation)

## II. Malignant tumors of bone

1. Osteogenic sarcoma
  - (a) Sclerosing type
  - (b) Osteolytic type
  - (c) Telangiectatic type
  - (d) Chondromyxomatous type
2. Ewing's (endothelial myeloma) tumor
3. Multiple (plasma cell) myelomata
4. Periosteal fibrosarcoma
5. Metastatic tumors (predominantly from breast, prostate, kidney [hypernephroma] and thyroid, less frequently from other viscera).

The great majority of this rather imposing group of neoplasms may be diagnosed readily clinically or by x-ray without the necessity of resorting to biopsy, but there still remains a very considerable group in which differential diagnosis may depend in the last analysis wholly upon microscopic study of the tissues, or in which the therapy may be materially influenced by a histologic evaluation of the neoplastic process. Furthermore there are many *tumor-like* lesions which add to the difficulties of the clinician; the roentgenologist and pathologist alike. It is in the recognition of this latter group of cases, and their differentiation from true neoplasms that biopsy studies are especially worthwhile. Among the more important, and more frequently encountered of these should be cited the following:

- I. Lesions involving epithelium
  1. Verrucae (especially the large, flat verruca plantaris)
  2. Certain of the chronic granulomata—among them blastomycosis, streptothricosis and even the tuberculides
  3. Molluscum contagiosum
- II. Lesions involving the soft tissues
  1. Ganglia of the tendon sheaths
  2. DeQuervain's disease (chronic tenosynovitis)



3. Gout
  4. Myositis ossificans (especially the localized traumatic type)
- III. Diseases of bone
1. Infectious lesions
    - (a) Atypical osteomyelitis
    - (b) Brodie's abscess
    - (c) Sclerosing osteitis
    - (d) Syphilitic osteitis and periostitis
    - (e) Tuberculosis of bone
  2. Metabolic and deficiency diseases
    - (a) Osteitis fibrosa
    - (b) Osteitis fibrosa cystica
    - (c) Osteitis deformans
    - (d) Scorbutus (rare)
    - (e) Xanthomatosis (Hand-Christian-Schüller disease)
  3. Miscellaneous conditions
    - (a) Exostoses
    - (b) Enchondroses

In a brief presentation of the subject such as this it is obviously impossible to go into any detailed discussion of the pathologic differential diagnosis of the entire gamut of conditions outlined above. Accordingly, the majority of these lesions may be dismissed briefly, reserving the greater part of our consideration for a few of the more troublesome problems of diagnosis and prognosis.

I. *Epithelial Tumors.* The benign tumors of the skin, as papillomata, may at times cause difficulty in diagnosis clinically. Their differentiation from verrucae and other chronic inflammatory lesions, from molluscum contagiosum, and if pigmented, from melanomata, not infrequently requires microscopic study of a biopsy fragment or of the excised specimen itself. In most such superficial lesions, excision is usually the method of choice in treatment. Immediate frozen section examination of the tissue is not ordinarily indicated, and the pathologist has a better opportunity to study the material under ideal circumstances, and is able to give a well weighed expression of opinion as to prognosis and further treatment. Especially in differen-

tiating the simple pigmented papilloma and nevus from the malignant melanoma does this affect the prognosis for the patient and at times his subsequent treatment. Even the possibility of squamous cell carcinoma developing in such a papillomatous lesion must be reckoned with, and here again, the pathologic diagnosis may well be the determining factor in urging some life saving measure.

The adenomata of the skin developing from sebaceous or sweat glands and their malignant counterparts such as adenocarcinomata are an almost negligible group as far as the extremities are concerned. They exist more as pathologic curiosities than as diagnostic problems. The recognition of the lesion is certainly histologic in character, and probably as much a surprise to the pathologist as to the clinician.

Neoplasms of the basal cell type are relatively uncommon involving an extremity except in the very aged, in whom their significance is almost negligible. Rare instances of their occurrence in a somewhat younger age group are recognized. In such cases the lesions are apt to be multiple, relatively cellular, and to present the cystic adenoid type of picture, more often associated with the small benign lesions around the eye. A woman 44 years of age provided one such case which provoked a considerable discussion and difference of opinion among pathologists to whom the biopsy material was submitted. There were over 200 small lesions scattered over both lower extremities which responded to irradiation therapy very satisfactorily. This type of tumor presents its usual histologic features characterized by a proliferation of the basal cells of the epithelium in a relatively orderly and noninvasive fashion. The value of the biopsy is seen in the occasional case in which the rate of growth of the lesion seems excessive, for now and again the squamous cell element becomes stimulated to neoplastic activity and the tumor presents a microscopic picture of actual malignancy requiring rather more radical therapeutic measures.

On the other hand, epidermoid (squamous cell) carcinomata of the extremity, while certainly not commonly encountered, can scarcely be considered as rare tumors. Most often seen on the extensor surfaces of the more exposed skin areas such as the back of the hand and wrist, they are found much more commonly in males. The age incidence, chiefly in the sixth and seventh decades, is likewise helpful in their recognition and differentiation from their more common basal cell counterpart. Usually of a relatively low grade malignancy, with well defined histologic differentiation of their cells, with "pearl" formation, keratinization, and the presence of intercellular bridges, their recognition at biopsy should be easy. However, when such adult cell characteristics are lacking, their separation from atypical inflammatory hyperplasias of the epithelium is a challenge to the pathologist at times, and his decision may be one of vital importance to the patient. Such tumors behave as squamous carcinomata elsewhere—by lymphatic metastasis—and extension to the regional lymph nodes in this instance may well mean axilla or groin—raising a difficult problem for the surgical approach, and modifying prognosis accordingly. Extreme care and long experience in interpreting the histologic findings under such circumstances are necessary if the patient is to obtain the best possible subsequent treatment,—and then only through coöperation of the surgeon and the radiologist.

*II. Tumors of Connective Tissue Origin Other than Bone Tumors.* Among the benign tumors of connective tissue origin which are encountered in the extremities, the fibroma is the only one occurring with any numerical frequency. Such tumors are usually small, discrete lesions immediately beneath the epithelium and apt to be fairly well circumscribed, although at times this demarcation is not too well maintained grossly. The tumors ordinarily are relatively small in size and their treatment is simple excision. Only in the instance of the larger lesions does any question of malig-

nancy ordinarily enter, in which case, again, biopsy serves to establish the diagnosis. From the differential standpoint,



FIG. 1. Left hand. Squamous cell (epidermoid) carcinoma of unusually advanced and malignant character.

further, if these tumors are multiple, as they not infrequently may be, and are associated with similar subcutaneous nodules elsewhere over the trunk, their possible confusion with the neurofibromata must be recognized. At times it is only with the use of differential staining methods that histologic examination can clear the issue.

More rarely, lipomata are encountered in the extremities, most often as part of a generalized lipomatosis. Their differential diagnosis from sebaceous cysts may at times occasion some difficulty clinically, but surgical removal and histologic examination serve to settle any such uncertainty.

Theoretically, myxomata might be encountered, but certainly only as extremely rare tumors. Personally, I have never in my experience observed such a tumor, either

as a benign or a malignant neoplasm, involving an extremity.

From the malignant standpoint, fibrosarcomata and liposarcomata may arise either upon the site of a preëxisting benign tumor of the same prototype, or as malignant lesions from the outset. Such tumors, particularly the fibrosarcomata, are by no means uncommon. This is especially true if one takes into consideration that group of sarcomata believed to arise from the periosteum as the so-called periosteal fibrosarcoma. Here, biopsy is of extreme prognostic value in differentiating the much less malignant periosteal sarcoma from other forms of bone tumor with which, not infrequently, they may be mistaken, both clinically and roentgenologically, invading as they frequently do the bone itself. Such tumors microscopically show all gradations of cellular differentiation from extreme anaplasia to relatively adult, compact growths with little evidence of activity, and with corresponding variation in their prognosis.

*III. Tumors of Hematopoietic and Reticulo-Endothelial Origin.* The tumors of the hematopoietic and lymphoid apparatus are relatively unimportant in respect to the extremities, in that they are usually merely manifestations of a rather widespread systemic process. If one were to include the occasional instances of primary lymphoma, lymphosarcoma, and Hodgkin's disease of the inguinal or axillary lymph nodes as lesions of the extremities, then their numerical importance would increase considerably as these sites are comparatively common in the development of such tumors. On the other hand, leukemia infiltration of the skin and bones is not materially affected either diagnostically or prognostically by biopsy examination. As in the case of the connective tissue tumors, the endothelial myeloma (Ewing's tumor of bone) deserves special consideration. It will be discussed in relation to the other bone tumors.

*IV. Tumors of Muscle Cell Origin.* Occasionally small myxomata arising from

the erector pili muscles in the subcutaneous tissues are encountered which are usually diagnosed clinically as a variant of the fibroma. It is only by pathologic examination of the tissues microscopically after their removal that their differentiation from this other more common subcutaneous tumor is made. Like the fibroma, such tumors are not ordinarily of any serious prognostic significance. Among the really rare tumors of the extremities should be mentioned the rhabdomyosarcoma, a malignant tumor arising from striated muscle. In a fairly wide experience with surgical pathologic material, only one such case has been encountered, arising from the gastrocnemius muscle of a young male. This remained localized, except for infiltration of the bone. Recovery was complete following amputation.

*V. Tumors of Pigment Cell Origin.* In the pigmented group of neoplasms, on the other hand, we encounter one of the most important groups of tumors of the extremities. Nevi of varying degrees of pigmentation and epithelial overgrowth, ranging from huge, elevated, pigmented, hirsute lesions down to tiny areas scarcely more than a millimeter or two in size with little or no pigmentation, are found in large numbers. Size, the degree of pigmentation, the amount of epithelial papillation, and regularity of outline, individually are not safe criteria for clinical differentiation of malignancy. Many innocent-appearing, small tumors have been removed and submitted for pathologic diagnosis only to be reported as malignant melanoma, and to be followed by the death of the patient within a comparatively short period of time thereafter; while, on the other hand, some of the most malignant-appearing lesions clinically and grossly may, under the microscope, show not the slightest suggestion of actual danger.

Perhaps among the most important of these melanomata, from this standpoint, should be mentioned the non-pigmented (amelanotic) melanoma which is so frequently encountered arising as a subungual

nodule in relation to one of the toes. These are frequently mistaken for inflammatory lesions and treated at first conservatively,

More significant from the surgical standpoint are those localized tumors involving the peripheral nerves of the extremities,

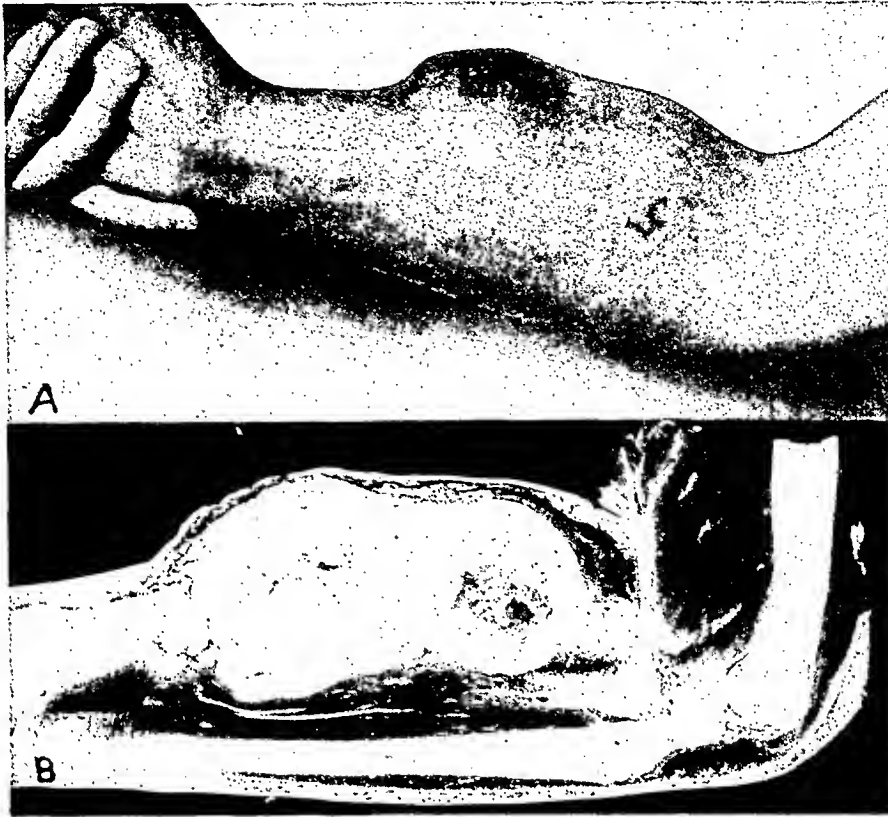


FIG. 2. Neurogenic sarcoma of arm. A, clinical photograph of patient's arm, showing location of tumor and its external appearance. B, sagittal section of amputated arm with its nerve trunk origin shown. Note absence of periosteal or bone involvement.

only to discover their malignant nature with the onset of widespread metastases. The importance of biopsy examination, preferably by immediate frozen section, in these cases cannot be over-emphasized, for radical surgery with amputation of the toe yields a very high percentage of permanent cures, if operation is performed sufficiently early.

*VI. Tumors of Nervous System Origin.* The tumors of the nervous system which are found to involve the extremities are chiefly those relating to the nerve fibers. These range from the diffuse neurofibromatosis of von Recklinghausen's disease, in which not only lesions of the extremities are found, but widespread systemic involvement of the entire cutaneous nervous system.

which in their benign state are spoken of as "neurinomata," and in their malignant form as "neurogenic sarcomata." These are tumors which often require extremely careful study under the microscope by an experienced pathologist to differentiate the benign from the malignant forms. The neurinoma, in itself, from the standpoint of life, is of little more significance than the benign tumors of connective tissue or smooth muscle origin, while the neurogenic sarcoma, on the other hand, is an extremely persistent tumor tending to become more malignant as time goes on and ultimately to metastasize and cause the death of the patient. Unfortunately, it is an extremely radioresistant tumor. Furthermore, one is confronted always by the possibility that the malignancy has extended far beyond

the apparent local lesion and that the process is one which may recur at a point higher along the nerve trunk, even when

diagnosis, in the first place because it is most frequently found as a subungual, minute, pinhead sized lesion; and secondly,

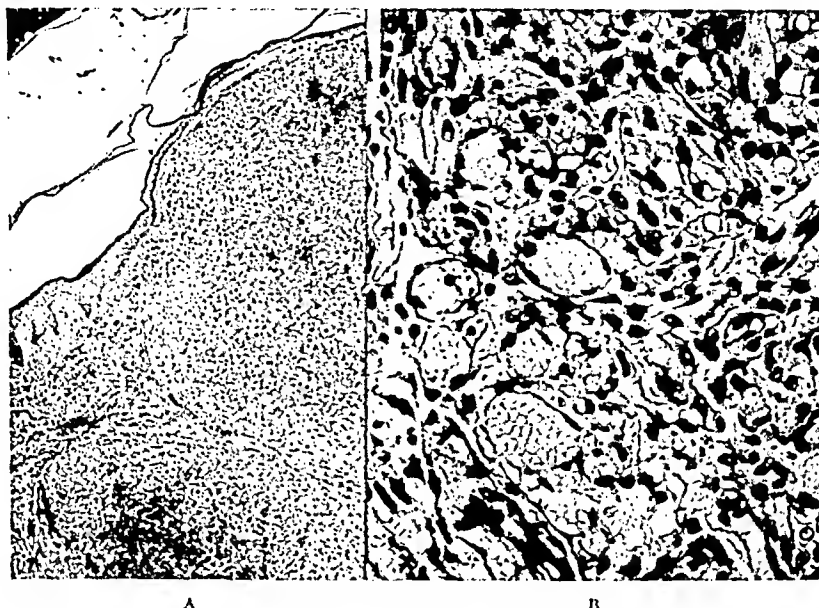


FIG. 3. Kaposi's disease of foot. A, low power photomicrograph to illustrate typical subcutaneous location of lesions with thinned overlying epithelium. B, high power architectural detail—emphasizing essential angiomatous nature of lesion and its low grade malignancy histologically.

fairly radical surgery by amputation has been done.

#### VII. Tumors of Endothelial Cell Origin.

Among the benign tumors which arise from angiomatous tissue must be mentioned the so-called "birth marks" or hemangiomas. Perhaps these should not be included as true tumors in any strict classification, as they are more probably developmental defects in the vascular system in intra-uterine life and are congenital in nature. Similarly, the lymphangioma, best exemplified by the so-called hygroma colli, might better be included as a congenital defect and be discussed under the heading of teratology rather than oncology. But at times their recognition is only established by biopsy study of tissue removed surgically.

Of more interest in this group of benign tumors which affect the vascular system is the glomus tumor, a growth which involves the neuromuscular vascular anastomoses. Clinically, it should offer little difficulty in

because of its involvement of the nerve fibers it is invariably one of the most painful lesions known. Its surgical removal results in permanent cure and the relief of the pain. Its diagnosis is merely confirmed by histologic examination.

On the malignant side, in the discussion of endothelial cell tumors, should be included that curious condition known as Kaposi's disease. This is believed by most pathologists to represent a true sarcoma of blood vessel origin and could well be spoken of anatomically as an angiosarcoma. For some curious and as yet unexplainable reason, the process almost invariably starts in one of the lower extremities and appears as nodular, purplish, cyanotic swellings of the skin which are frequently mistaken for some inflammatory process complicated by hemorrhage. The lesions are likely to occur in crops, which should lead the observant clinician to suspect the diagnosis. Biopsy examination reveals a rather characteristic picture of a

proliferative endothelial reaction of a sarcomatous nature as evidenced by numerous mitoses and the atypicality of the cells.

may only be accomplished by actual amputation. If excision is not complete, then the tumor may be expected to recur

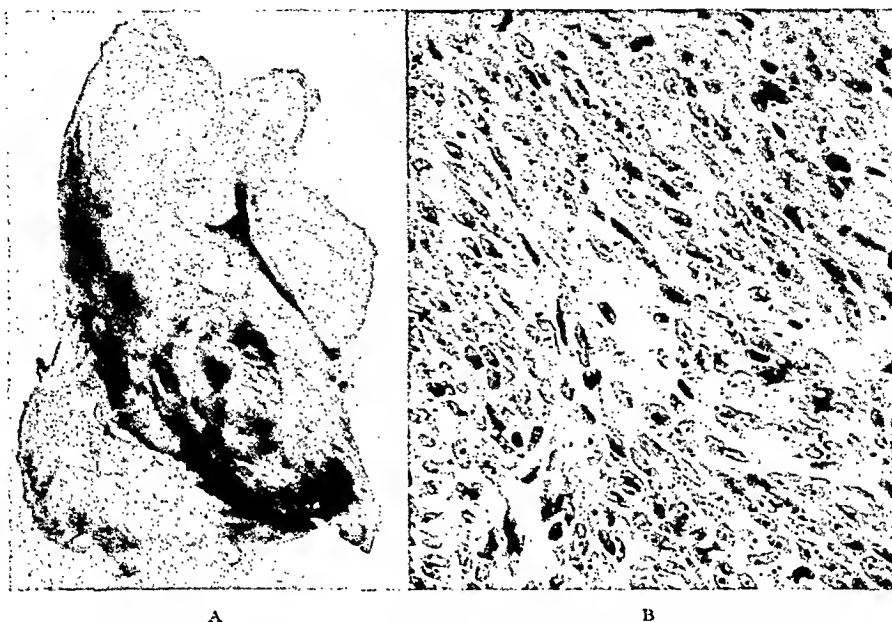


FIG. 4. Synovioma, invading os calcis. A, gross photograph of large, sausage-shaped mass under long arch of foot and invading os calcis. B, photomicrograph showing cellular structure of tumor. Undifferentiated spindle-shaped endothelial cells in irregular masses.

Temporarily, such patients may be relieved by irradiation, and it is held by some observers that early amputation may result in permanent relief. However, in our experience and in carefully combing the literature, no form of therapy seems to be of lasting benefit. It is our impression that conservatism is preferable, to avoid the shock of radical surgery which offers so little for any appreciable length of time.

Finally, in the group of tumors generally conceded as arising from endothelial cells should be mentioned the synovioma, a tumor ordinarily arising from the synovial lining of joint cavities, bursae and tendon sheaths. This is a tumor which is probably more common than is generally realized and might readily be mistaken by the inexperienced pathologist for a fibrous tissue tumor. Here again, biopsy examination seems to be of particular value as the great majority of these tumors are extremely slow in their development and if completely excised should not recur. The difficulty in the majority of cases lies in the technical difficulty of radical excision which

with increasing malignancy and ultimately to metastasize to the lungs and cause the death of the patient.

*VIII. Tumors of Bone.* The tumors of bone have been so thoroughly discussed in the literature in recent years, and have been so adequately reviewed in Geschichter and Copeland's monograph, "Tumors of Bone," that it would seem to serve no particular purpose to explore this field in detail. Rather, we are inclined to review the major varieties of bone tumors in relation to their differential diagnosis from other conditions with which they may readily be confused clinically, roentgenologically and even pathologically.

1. *Benign Bone Tumors.* Of the benign tumors of bone, we need only mention the fact that osteomata and chondromata may be encountered occasionally. Their chief interest lies in their differentiation from inflammatory exostoses, enchondroses and from their malignant counterparts. This may only be possible by very careful correlative studies by clinician, radiologist and pathologist.



More important than these tumors is the frequently encountered benign giant cell tumor. Its differentiation from chondro-

have an underlying parathyroid dysfunctional basis. The obvious importance of hematologic studies, and even of urinalysis,



FIG. 5. Osteogenic sarcoma of femur. A, gross sagittal section of chondromyxomatous type of osteogenic sarcoma of femur, destroying bone, but with marked chondroplasia. B, photomicrograph showing cartilaginous nature of tumor at left, and marked anaplasia of cells at right.

sarcoma, from osteitis fibrosa cystica and even from osteomyelitis and Hand-Christian-Schüller disease may at times present considerable difficulty. It has been our experience that the majority of these lesions may be recognized by history, clinical examination and x-ray studies, but that in the smaller group of somewhat indeterminate cases, biopsy is an entirely innocent procedure and leads to the correct diagnosis, which obviously may materially influence the form of therapy to be carried out. Here as in the previous instances cited, the closest possible coöperation between the clinician, radiologist and pathologist is most essential.

Indeed, one might carry this thought a step further and call to the reader's attention the not infrequent necessity of clinical pathologic examinations, especially blood chemistry studies relating to calcium balance, in an effort to determine whether any given case showing osteolytic changes such as are seen in giant cell tumor of bone may

in these cases is likewise not to be overlooked nor disregarded. The finding of Bence-Jones protein in the urine may be the necessary clue to the establishment of a correct diagnosis of myeloma in a previously unsuspected case. Changes in the Schilling index, even when the total white count is not abnormally elevated, may in turn suggest that the process is an infectious, inflammatory one of a low grade and again lead to proper diagnosis and treatment.

**2. Malignant Bone Tumors.** Of the malignant forms of bone tumor, those which primarily arise from the bony or cartilaginous elements of the bones are best included under the generic term of osteogenic sarcoma. There is little occasion to call attention to the comparatively well known features of these lesions in view of the widespread dissemination of knowledge regarding bone tumors in general since the formation of the Bone Tumor Registry by E. A. Codman of Boston, and its sub-



sequent expansion under the American College of Surgeons. The differential diagnosis of osteogenic sarcoma from Ewing's endothelial myeloma or even at times from the benign giant cell tumor may cause considerable difficulty. In general, however, a carefully extracted clinical history and thorough roentgenologic studies should suffice to establish the diagnosis in the majority of cases. It is our belief, however, that a certain proportion of these cases do offer difficulties in clinical diagnosis and, as in the case of the benign giant cell tumors already cited, should be studied in conjunction with the pathologist, and biopsy examination made. It is probably preferable to plan such a biopsy as an immediate frozen section type of study so that the required operative procedure with radical amputation can be carried out as soon as diagnosis is established. While it is our own belief that statistical studies do not reveal any definite increased danger of causing metastasis by such a biopsy procedure followed by an interval before surgery is done, yet one cannot but feel that if such a possibility does exist, then it is more likely to occur in a case of this type where the invasion of the vascular system could most readily occur.

With the early diagnosis of an osteogenic sarcoma, and it is in the early case that biopsy is particularly indicated, statistical studies have shown that there should be nearly a 20 per cent chance of recovery if amputation is done. If the pathologist could impress upon the clinician the importance of thorough study of cases in which the diagnosis of bone disease is even remotely suspected, it is quite possible that these figures of five and ten year cures of osteogenic sarcoma could be materially increased.

In respect to Ewing's endothelial myeloma tumor, again biopsy, either as a puncture aspiration procedure or as a more radical actual excision of tissue, may be the most satisfactory way of establishing the diagnosis in early and atypical cases. The significant factor in the determination of

such a diagnosis lies in the totally different prognosis as compared with that of the osteogenic type of sarcoma and in the fact that therapy except under most unusual circumstances should be irradiation rather than surgery to give the patient the best possible opportunity for recovery.

Of the multiple myelomata of the plasma cell type, little need be said. The disease is not confined to the extremities. Indeed, the extremities are often among the last of the skeletal structures to be attacked. The diagnosis is often wholly a radiologic one in conjunction with the clinical findings, but may well be substantially confirmed by clinical pathologic studies of the blood and urine. In this fortunately uncommon group of cases there seems to be little indication for biopsy in order to prove the diagnosis.

Finally, the group of metastatic tumors which invade the skeletal system must be considered very seriously as a diagnostic problem which frequently confronts the pathologist as well as the clinician and radiologist. These tumors are predominantly carcinomatous, arising chiefly from one or another of the glandular organs, notably the breast, prostate and thyroid, and less frequently from the gastrointestinal tract, kidney, adrenal and other organs. In no group of cases is a careful history more important, for what might ordinarily appear to be irrelevant, unimportant facts loom significantly in a review of a case in the establishment of the final diagnosis. As an example, I might cite a case of a woman in her middle forties who had had a small nodule removed from her breast eight years previously. This information was obtained only after a very extensive study of the case had revealed widespread osteolytic lesions in the long bones of the lower extremities. The patient had completely forgotten the incident because at the time she had been told the lesion was benign and had given it no further thought. The roentgenologic findings were atypical in their diffuseness and there was a very marked anemia which led to a wide variety of opinions and a very

intensive therapeutic barrage to overcome what was subsequently shown to be a myelophthisic anemia due to metastatic tumor invasion throughout the skeleton. Upon the insistence of the pathologist, a biopsy from one of the bone lesions was finally obtained and the diagnosis established.

In the same way, so many instances of metastatic carcinoma of the prostate occur without prominent clinical symptoms of prostatic disease, and unless the history is gone into in unusual detail, minor changes in bladder habits may well be overlooked and attention diverted to some totally unrelated condition.

In the further differential diagnosis of bone lesions, I should like to call attention to one group of cases which I believe merits more consideration than has been given it in the past. This is a lesion which affects usually the long bones of the lower extremities, not infrequently involving such bones as the os calcis. It is perhaps best known by the term sclerosing osteitis. It has been our good fortune to have the opportunity, through the coöperation of Dr. John Royal Moore, of studying a series of such cases. Here as in perhaps no other single instance does the final differential diagnosis depend upon biopsy study. The differential diagnosis from bone tumor, particularly osteogenic sarcoma, by x-ray, except in the hands of the most experienced radiologists who are familiar with this condition, is almost impossible and has been frequently erroneously reported. I am convinced that a certain number of instances of cured osteogenic sarcomata which have been reported by clinicians and radiologists without the subsequent confirmation of pathologic study represent such cases of sclerosing osteitis. The age incidence is similar, the cases occurring particularly in the younger age group, more frequently in

males, and characterized by the usual history of antecedent trauma followed by progressively increasing pain. Clinically the degree of pain is out of proportion to the clinical and radiologic evidence of any bone lesion. This alone should raise the question of diagnosis in the surgeon's mind. Roentgenologically, not infrequently, there is marked thickening of the cortex which may be accompanied by osteogenesis and bone spicule formation.

The disease is probably a form of sub-acute infection which involves the periosteum and cortex of the bone rather than the medullary canal and becomes sealed off from the medullary canal by the proliferative reaction which closes the entire Haversian system in the area involved. It is this interference with the blood supply and the pressure upon the thickened and elevated periosteum which apparently produce the symptoms. Clinically, relief is obtained by reëstablishing the cortical circulation either by guttering the cortex or by perforating it with multiple adequate drill holes so that new vessel formation can take place. Diagnosis depends in the majority of these cases upon the histologic study of this bone, which shows evidence of hyperplastic sclerosis but not of neoplasia.

Of the other lesions which have been listed in the early part of this report as among those causing difficulty in diagnosis and requiring histologic study by the pathologist, none perhaps needs further detailed comment. It is well, however, to reiterate the difficulties which the clinician may have in arriving at a correct diagnosis in many of these conditions without the coöperative help of the radiologist and pathologist, and to recognize the importance of such combined efforts in improving our methods in diagnosis and treatment for the ultimate benefit of the patient and mankind.



# DISTURBANCES OF THE METATARSAL ARCH AND AN AID TO CERTAIN STATIC FOOT CONDITIONS

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## DISTURBANCES OF THE METATARSAL ARCH

FOR a long period it was a general conception that nearly every disturbance involving the metatarsal arch was a "Morton's toe." The term "metatarsalgia," meaning pain in the metatarsal region, is a symptom and does not describe the pathologic condition.

In the January, 1876 issue of *The American Journal of the Medical Sciences*, Thomas G. Morton of Philadelphia reported "a peculiar and painful affection of the fourth metatarsal phalangeal articulation" which has since been recognized as Morton's toe or Morton's neuralgia. He wrote "In those cases the pain has been localized in the fourth metatarsal-phalangeal articulation; in several instances it followed an injury of the foot, in others it gradually developed from pressure, while in others there was no recognized cause." In a report covering the histories and treatment of twelve cases, he said: "Of the twelve cases which I have reported, eleven have occurred in females."

Morton ascribed the neuralgia to the peculiar position which the fourth metatarsal-phalangeal articulation bears in relation to that of the fifth, the great mobility of the fifth metatarsal, which by lateral pressure is brought into contact with the fourth, and lastly, the proximity of the digital branches of the external plantar nerve which are, under certain circumstances, liable to be bruised by, or pinched between, the fourth and fifth metatarsals. He attributed the greater incidence in females to the greater delicacy and pliability of the female foot as compared with the male foot, and perhaps in a measure to the prevailing custom, especially with fashionable women, of wearing

tight and very narrow shoes. The fifth metatarsal is thus pressed against the head and neck of the fourth. The phalanx of the fifth especially is forced down upon the head of the fourth and its associated phalanx.

The metatarsal arch is a curved structure seen on the side or oblique view of the skeleton, extending from the tarsometatarsal articulations to the end phalanges or at least to the proximal interphalangeal joints.

The skeleton of these parts consists of the metatarsal bases, shafts and heads. The proximal phalanges and sesamoids are accessory structures often affected by metatarsal disturbances. The metatarsophalangeal joints are simple ball and socket joints surrounded by capsules lined with synovial membranes. They are subjected to stress, strain, injury, growth disturbances and infections. The muscles of this region are the plantar and dorsal interossei, the lumbricales and the adductor hallucis. The tendons are the flexors and extensors of the toes, the abductors and adductors, and the peroneus longus. The plantar fascia is an important structure. The interdigital vessels and nerves at times demand special consideration. There are bursae between the metatarsal heads. The skin of the plantar surface of this area is unusually thick.

The functions of the metatarsal regions are to afford stability in locomotion, to permit spring and resilience to the step and to relieve the spine and central nervous system of jars. The transverse arch is highest near the tarso-metatarsal joints, and gradually lowers toward the metatarsal heads. The arch protects the nerves, vessels, muscles, tendons and ligaments from injury.

The transverse arch is maintained by the transversely directed dorsal, plantar and interosseous ligaments. The obliquely directed peroneus longus tendon and to some extent the expansion of the tibialis posterior tendon, afford some support. When the transverse arch is properly maintained, the anterior pillar of the longitudinal arch rests on the heads of the first and fourth metatarsal bones only; that of the fifth also presses on the ground in many cases, especially when more weight is borne on the foot. If the transverse arch yields, the heads of the intervening metatarsal bones receive undue pressure and periostitis and callosities develop under them. The lumbricales and interossei muscles fix the toes to the ground in walking and are important sustainers of the arch. When these groups of muscles are paralyzed or weakened, the toes assume a position of "claw toe" and the normal gait is interfered with. If the toes are forced to assume a position of clawing by any cause, such as improper shoes, these two groups of muscles are unable to function properly, and the unopposed action of the extensor muscles aggravates the clawing and depresses the metatarsal heads. The transverse head of the adductor hallucis approximates all the toes, thereby increasing the curve of the transverse arch. The metatarsal arch is curved in two directions, laterally and anteroposteriorly. The structure formed by the metatarsal heads is the true transverse arch.

**Etiology.** The etiology of metatarsal disturbances is varied. Very common in adult patients, metatarsalgia is comparatively infrequent in childhood, during which period many of the cases are due to osteochondritis, a condition described by Freiberg as infraction of the metatarsal head. I have treated at least twenty such cases. The cause is thought to be trauma to growing epiphyses, which interferes with normal local circulation and growth. Metatarsal troubles are more common in the female, undoubtedly the result of improper shoes and incorrect shoe fitting.

Short stockings or the forceful pulling of stockings are additional factors. Heredity may be important, especially in arthritic and pes cavus cases.

Arthritis is an important cause of metatarsalgia. Infections of various types contribute a fair share of these cases. The infection may be local or focal such as infected teeth, tonsils, sinuses and abscesses of the pelvis or from an infection like influenza, may be a causative factor. Static disturbances, such as prolonged standing on hard floors or other surfaces, predispose to metatarsal disturbances. Traumas of various sorts are important, among which may be mentioned the sprain or strain as seen in the chauffeur's foot or in the dancer's foot, especially while toe dancing. The trauma from shoes has been mentioned. Injury by falling objects or being stepped on by another person or by an animal may cause metatarsalgia.

Inflammation of the metatarsal bursae produces metatarsalgia. Roberts describes a type of bursitis which gives rise to a disabling soreness sometimes confined to the ball of the foot, sometimes extending upward and backward, and sometimes accompanied by puffiness of the adjacent soft tissues. The pain subsides when the foot is at rest and recurs when standing or walking is resumed. Acute twinges of pain occur in stepping on an uneven surface such as cobblestones or streetcar tracks because sudden pressure is brought upon the distended sacs. Royle also described metatarsal bursitis. Hertzler recalls that there are in the region of the metatarsophalangeal articulation three sets of bursae: (1) the intertarsophalangeal, the largest and those usually involved; (2) the bursae below the heads of the metatarsal bones; and (3) those about the tendons in this region. Hertzler believes that some of these cases are examples of "anterior plantar bursitis" (metatarsal neuralgia). Subsequent writers have followed Morton's conclusions with serious doubt.

The more frequent occurrence of the pain about the fourth metatarsal head was ascribed to the fact that the fifth meta-

tarsalgia. Spastic paralysis, plantar fasciitis, paralgia hyperaesthetica are causes of metatarsalgia; also the following conditions:

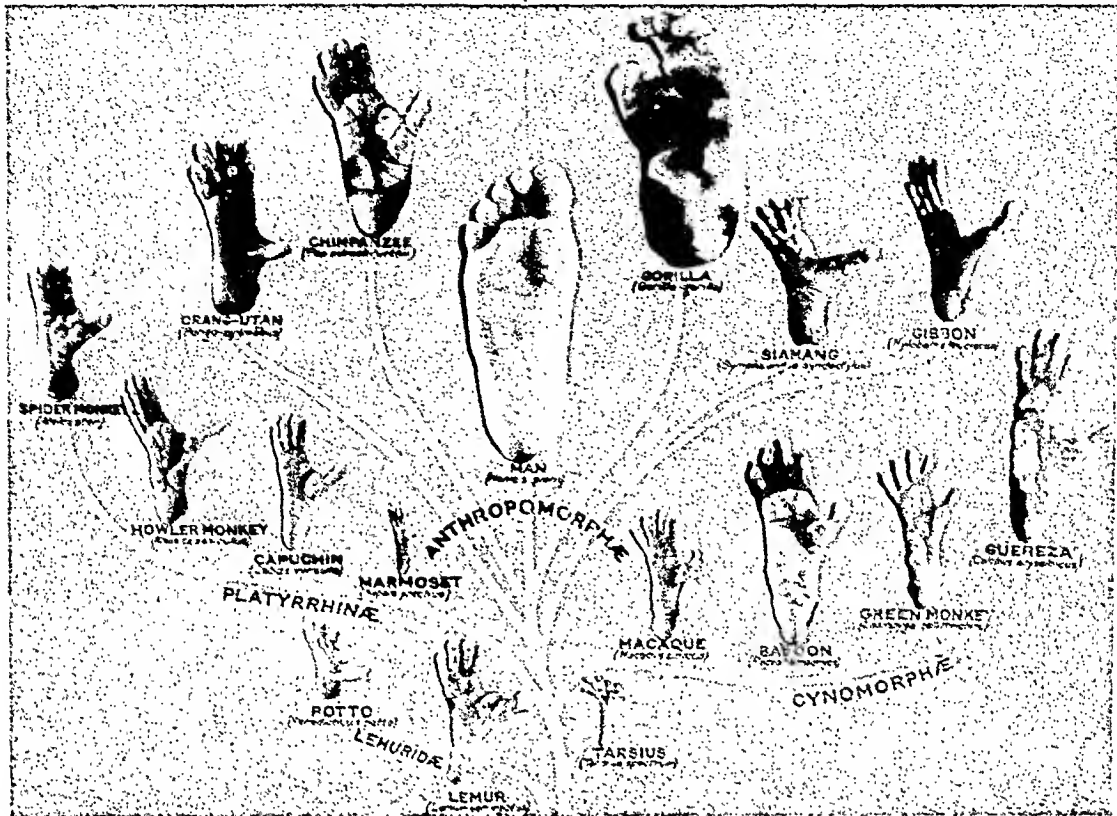


FIG. 1. Feet of primates, man and monkeys. (Courtesy The American Museum of Natural History, New York.)

tarsal bone being shorter allowed its head to impinge on the nerve. The removal of the head of the bone was supposed to relieve this impingement.

Hertzler calls attention to the fact that in the removal of the metatarsal head the bursae lying beside it also were removed. He believes that the removal of the bursae alone might effect a cure.

I have seen a nurse who developed metatarsalgia following the accidental shooting off of all her toes. I have also seen a surgeon who had metatarsalgia following a septic infection of the metatarsal region, as a result of the piercing of his shoe by an infected scalpel which dropped during an operation. Amputation, bunion operations, and hammer toe operations are frequently followed by metatarsalgia, often, however, present but unrecognized before the operation. Fractures, dislocations and thermal and chemical burns may cause meta-

pes cavus that is independent of, or coincident with, spina bifida, sometimes appearing at puberty; circulatory lesions such as endarteritis; thrombo-angiitis obliterans; Raynaud's disease; causalgia; frostbite, chilblains; trench foot; and soft corns. I have seen several cases of incomplete amputation of the toes which resulted in metatarsalgia.

**Pathology.** The pathologic changes are anatomic or mechanical plus infectious or toxic factors. The anatomic considerations are depression or inversion of the arch which normally is convex above. There results pressure on the interdigital nerves and relaxation of the capsules and ligaments. Periostitis of the metatarsal bone may be found. Bursitis was described above. Papillomas and soft corns, usually between the fourth and fifth toes, are common. The infectious factor is similar to that in any other joint.

**Symptoms.** The symptoms of metatarsal depression are pain, rigidity and at times spasm and contractures of the

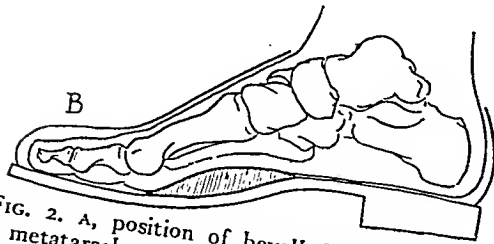
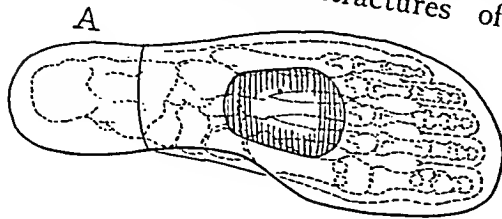


FIG. 2. A, position of bevelled felt pad for metatarsal arch with relation to the metatarsal bones. B, position of pad in shoe.

extensor muscles. The physical conditions of metatarsal depression are the inversion of the arch, callus formation, sensitiveness and tenderness which may be due to periostitis of the metatarsal bones. Every schoolboy knows that if he can grasp another boy's hand, depress the knuckles and exert lateral compression, he can cause pain. An analogous condition is found in a depressed metatarsal arch.

**Diagnosis.** Roentgenograms, although not always necessary in making a diagnosis, should be made routinely. A good history and careful examination are usually more valuable. Lateral roentgenograms reveal the depression on lateral view; and may show bunions, "bunionettes" (exostoses of the fifth metatarsal sesamoids, the position and integrity of the phalangeal osteochondritis).

Deutschlander's disease affects usually the shafts of the second or third metatarsals. It appears to have a spontaneous origin and the findings may be divided into three stages: a period of about two months during which there is a localized tender spot but no roentgenographic changes; a second period during the fourth month when there is new bone formation, and a

third period or stage of cure with diminution of callus. Peremans believes that Deutschlander's disease is due to a fracture between the middle and the lower third of the metatarsals due to improper statics and may occur spontaneously in a bone previously unaffected.

**Prognosis.** The prognosis depends on the pathologic condition and the coöperation of the patient in carrying out proper treatment.

**Treatment.** The treatment of the usual type of metatarsalgia consists of local and general measures; the latter being removal of foci of infection and the correction of metabolic, hygienic and dietetic disturbances. The local treatment consists of relief from inflammation or irritation, proper shoes and shoeing, metatarsal support, and the physiologic restoration of power of the supporting structures of the arch. Relief from irritation and inflammation may be accomplished by rest and non-weight-bearing. In the severe cases rest is necessary, with the application of an anodyne lotion used in conjunction with fomentations and elevation of the feet.

R	
Tinct. opii.....	30
Liq. plumbi subacet. dil.....	40
Phenolis $\frac{1}{2}$ per cent.....	50
Ext. hamaemelidis.....	60
M. et. ft. lotio	
Sig. Externally as directed.	

Compartment A

Compartment B

1. Apply four layers of gauze over entire foot and ankle.
2. Saturate the gauze with the lotion after the bottle has been well shaken.
3. Apply oiled muslin, silk or rubber sheeting.
4. Apply four layers of flannel or wool wrung out of hot water.
5. Apply oiled muslin, silk or rubber sheeting.

- Compartment C {
6. Add hot water bottle to the side of the dressings.
  7. Cover everything with a turkish towel.
  8. Elevate leg and foot.
  9. Add more lotion twice daily.
  10. Keep water bottles hot continually from 9 A.M. until 9 P.M.
  11. From 9 P.M. until 9 A.M. use an anodyne ointment plus dry heat.

Shoes must be of straight last, round toe, medium width shank and moderate height heel. The flexibility or rigidity of the shank depends upon an accompanying disturbance of the longitudinal arch. The fitting of the shoe is very important. Custom made shoes are often too short. The shoe may be modified by the addition or insertion of a metatarsal bar, crescent or preferably a comma bar. Properly shaped and bevelled felt pads are inserted in the shoe to support the depressed structures. The pads may be applied directly to the foot temporarily, secured by means of a resinous glue and strips of adhesive plaster or by means of a simple elastic metatarsal cuff, which in itself has some value in supporting the arch laterally. A laced leather cuff is preferred by some. An adhesive plaster compression band around the waist of the foot often affords considerable temporary relief.

The felt pad is usually inserted directly into the shoe, being secured by means of glue. An insole is not essential. Because it is not physiologic to compress the delicate foot muscles between the rigid bones above and a rigid object below, I practically never use a metal plate to support a depressed metatarsal arch, depending entirely on the resilient support of the felt pad. Sponge rubber may be used. The patient's hose should be long enough and must not be drawn too tightly. Massage of the feet twice daily with an anodyne ointment is

beneficial. Contrast foot baths afford the feet a valuable tonic.

Special exercises are of the greatest value

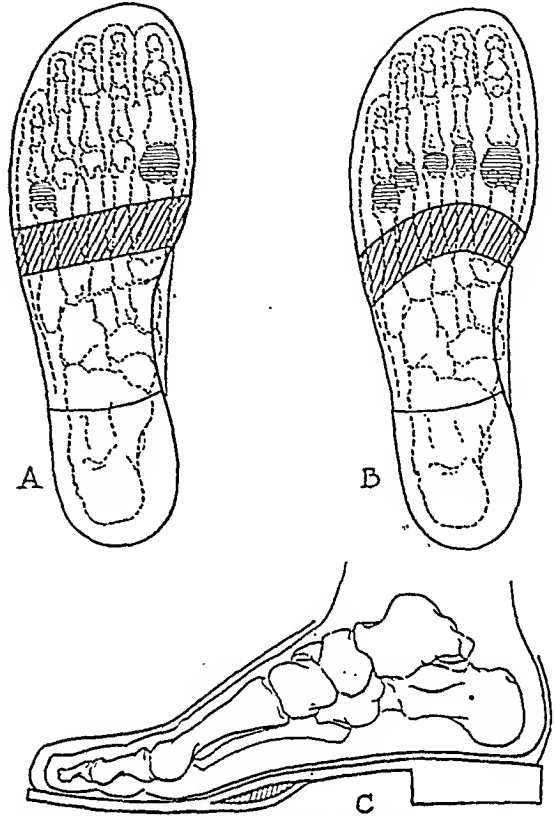


FIG. 3. A, position of bevelled leather metatarsal bar usually  $\frac{3}{8}$  inch thick and 1 inch wide. B, position of metatarsal crescent in relation to heads of metatarsal bones. C, side view of shoe and foot with cleat in position.

in increasing the power of the supporting structures and the flexibility of the metatarsal arch. Numerous exercises have been described and recommended. The following have been found of much value (each exercise is done with the bare feet twice daily).

1. *Door Stop Exercise.* Two old fashioned door stops obtainable at the hardware section of a 5 and 10 cent store, are prepared for use by removal of the rubber tips with a pair of nippers. They are then screwed into a board about 14 inches long, 8 inches wide and 2 inches thick. The centers of the door stops should be 6 inches apart. A heel rest the same height as the door stops ( $2\frac{3}{8}$  inches) is added.

The board is placed on the floor, and the patient sits on a chair in front of it. Each foot is placed with heel on the heel rest and



metatarsal arch on a doorstep, with very slight pressure just behind the metatarsal heads or calluses. On the count of 1, the

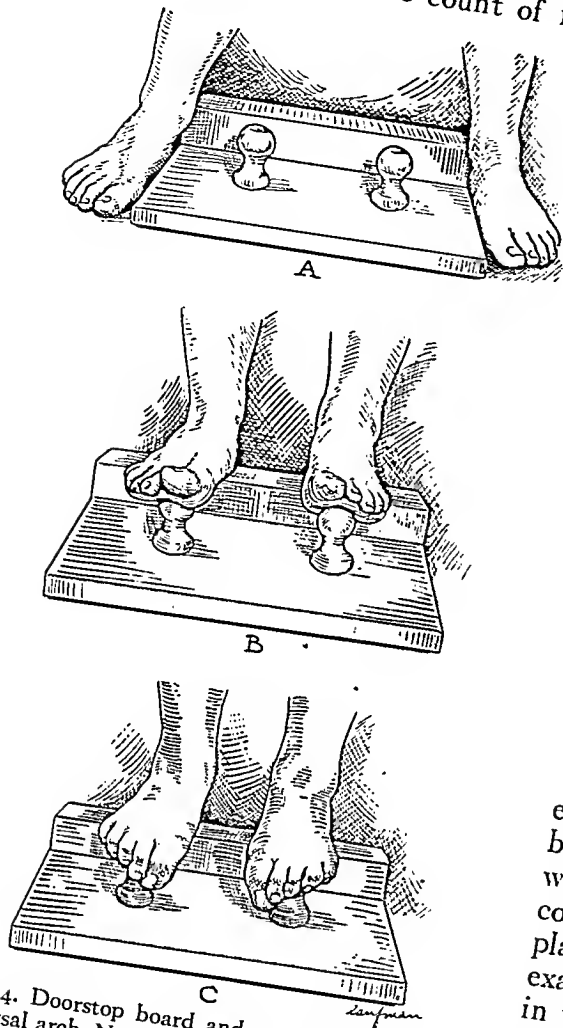


FIG. 4. Doorstop board and exercise for metatarsal arch. No ankle valgus is permissible.

toes are forcibly curled down, and on the count of 2 they are allowed to relax slowly. This is continued until one has counted 200. (This number should be attained gradually.)

2. *Towel Exercise.* The patient sits on a chair. A large hand towel is spread on the carpet, with the narrow edge facing the patient. The feet are placed so that the posterior half of each foot is on the towel. The towel is grasped with the toes of one foot, then with the toes of the other toes of one foot grasp, those of the other relax. This is carried out until the entire towel is under the feet.

3. *Golf Ball Exercise.* A golf ball is placed on the rug and rolled under the metatarsal arch for one minute. Then it is picked up with the toes of one foot and placed under the toes of the other foot, and the exercise is repeated for another minute. The patient alternates in this manner six times.

4. *Rubber Ball Exercise.* A small rubber ball may be used as substitute for the golf ball.

5. *Marble Exercise.* Marbles of various sizes are placed on a rug. The patient sits on a chair and picks them up with the toes.

6. *Pencil Exercise.* A round pencil is placed on a hard floor and by means of the toes, curled downward, the patient pushes and pulls the pencil around the floor with short, quick movements.

*Massage.* This should be done for five minutes each morning and night. It is desirable that the patient lie down while another massages his feet. Do not rub, but use a deep rotatory movement.

*Contrast Baths.* Obtain two buckets, each large enough to contain both feet. Fill bucket No. 1 about two-thirds full of warm water, and bucket No. 2 two-thirds full of cool water. Sit alongside of the buckets, place both feet in the warm water for exactly one minute. Remove feet and place in the cool water for exactly one minute. Alternate in this manner for ten minutes, i.e., five in each bucket. This routine is to be carried out twice daily.

*Contrast Sprays.* Sit on the side of the bath tub and spray both feet with warm water for exactly one minute; then with cool water for exactly one minute. Alternate in this manner for ten minutes, twice daily.

When massage, exercises and contrast baths are prescribed, they should be carried out in the following order:

Mornings: massage, exercises, contrast baths.

Nights: contrast baths, exercises, massage.

Inductotherm, negative galvanism and sinusoidal current are helpful adjuvants in

the treatment. Plaster of Paris casts are occasionally indicated. Less frequently operation is necessary. The various operations in this region are tenotomy, tenodesis and tendon transplantations such as the Jones or Sherman operations. Hoffman's operation, consisting of removal of the metatarsal heads, should be reserved for extreme cases. Murk Jansen tenotomized the transverse head of the adductor hallucis with excellent results. Spitzzy restored the metatarsal arch by a silk suspension ligature passed around the heads of the first and the fourth metatarsal bones. Arthrodesis and arthroplasty of the four outer metatarsal joints is rarely indicated.

#### HYPERMOBILITY OF THE FIRST METATARSAL BONE

D. J. Morton describes a condition of hypermobility of the first metatarsal bone which is due to unusually free motion in the joint between the inner cuneiform and scaphoid bones, and between the inner and middle cuneiforms. The resulting instability of the inner anterior pillar affects both the metatarsal portion, and the longitudinal arch of the foot.

Physiologic hypertrophy of the second metatarsal bone is the most notable structural feature. Metatarsalgic symptoms are more frequent than symptoms of longitudinal arch strain.

D. J. Morton believes that the term "anterior metatarsal arch" is an anatomic misnomer. The ball of the foot assumes transversely a more or less concave form when in a passive state; but in a weight-bearing foot the heads of all the metatarsal bones lie in a single horizontal plane—each one having direct contact with the ground or supporting surface. In other words, there is no real arched conformation maintained in this part.

D. J. Morton states that the clinical word "metatarsalgia" is commonly used interchangeably with the term "depressed anterior arches." But since the heads of the metatarsal bones lie on the same horizontal plane in their functional relationship, and

because of the usual solidity of the supporting surface, there can be no actual depression of the middle ones.

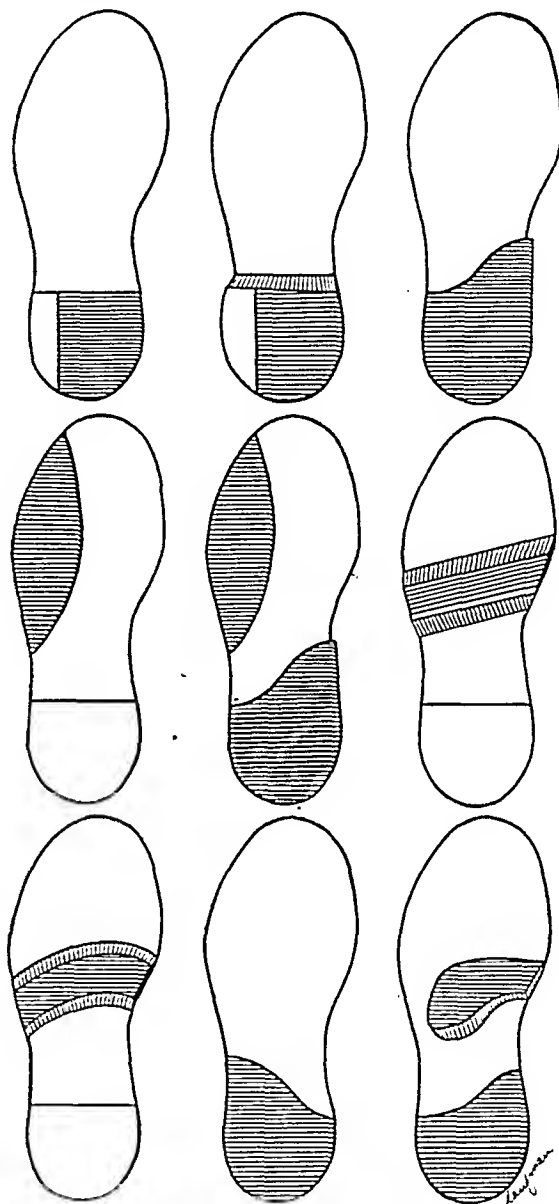


FIG. 5. Various types of shoe modifications or adjustments.

Hypermobility has been observed to be a very common factor in the "weak feet" of children.

Some cases of hypermobility are suitable subjects for either the flat-foot operation described by Miller or that of Morton. In the latter method, arthrodesis is performed between the inner and middle cuneiform bones, and between these two bones and the scaphoid.

Dudley J. Morton reported thirty-four cases which presented different degrees of

"arrested" development of the first metatarsal bone, attended with symptoms suggesting the ordinary type of meta-

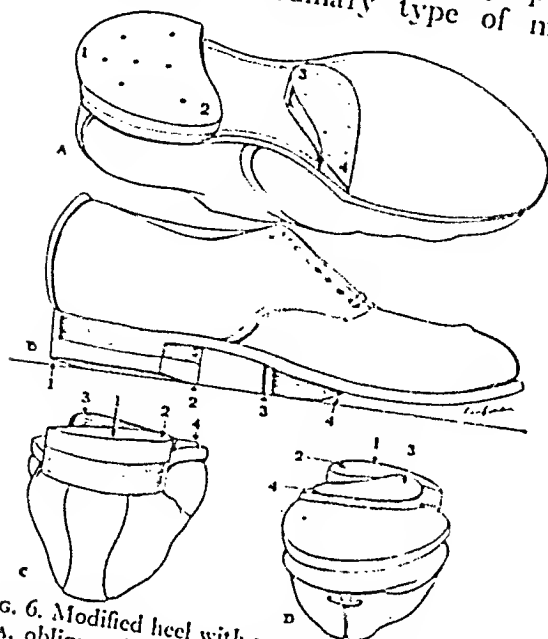


FIG. 6. Modified heel with metatarsal comma bar. A, oblique view of sole of shoe. B, side view of sole of shoe. C, rear view of heel and sole. D, front view of sole and heel.

tarsalgia, or having a definite history of "Morton's toe." Twenty-eight of these patients were adult females. In twenty-nine of the thirty-four cases the symptoms have been of the milder metatarsalgic character, only five giving histories of acute paroxysms of pain.

#### METATARSUS ATAVICUS

A painful disorder of the anterior portion of the foot, to which the term "metatarsus atavicus" has been applied by Dudley J. Morton, presents two characteristic signs. The first is a morphologic one, manifested in the unusual shortness of the first metatarsal bone as compared with the length of the second. The other is the clinical symptom of tenderness elicited by deep pressure on the sole of the foot in the region of the second metatarsocuneiform joint. The head of the second metatarsal bone is definitely in advance of that of the first. Associated with the more extended position of the second metatarsal bone, there is an increase in the transverse diameter of its shaft and

in the thickness of its dense cortical walls. It presents a marked contrast to the lateral slenderness of the three outer metatarsal bones, and may even exceed the breadth of the first metatarsal.

The most frequent complaint is indefinite discomfort or pain in the forepart of the foot, brought on by an unusual amount of active function such as walking, dancing, tennis playing, or by prolonged standing. One of the earliest and most transient symptoms is a burning sensation in the ball of the foot, following an excessive amount of foot function. This sensation is later replaced by pain of a sharper, more acute character, or by dull aching pain. In some cases, the pain is of a sudden, spasmodic character located usually about the head of the third or fourth metatarsal bones, extending into one or the other of the toes and sometimes up the leg.

When the foot is viewed dorsally, the great toe is often shorter than the second, although this difference is sometimes obscured by an habitual flexion of the distal phalanx of the latter. Plantarily, the ball of the great toe appears set well back on the forward extension of the fleshy area beneath the heads of the second and third metatarsals. In a majority of the cases a callosity is located under the head of the second metatarsal bone.

The characteristic clinical sign is the tenderness which can be recognized on deep palpation of the sole of the foot, about the juncture of the middle cuneiform bone with the base of the second metatarsal.

#### METATARSAL EQUINUS

Metatarsal equinus is a term used by Hoke to describe all deformities of the feet in which there is an equinus or cavus element. They are painful feet. A small percentage of them need to be operated on. In metatarsal equinus the anterior ends of the metatarsals are pitched down, and are found just beneath the skin in the ball of the foot. Calluses form beneath them. The ball is painful from the digging of the

anterior ends of these bones down into the ball of the foot when standing or walking. There is also an enlargement of the inferior part of the anterior end of the metatarsal bone. This becomes an added source of pain because of pressure.

The basis of Hoke's operation has been to remove the anterior two-thirds of the metatarsal bone, after subperiosteal dissection, operate on the bone while it is out of the wound and immediately reimplant it in its periosteal bed, setting it in a way so that a normal mechanical and anatomic situation exists thereafter. He advises taking the bones out, shortening them a little, pitching the toes down, and reimplanting the bones turned upside down. In all, forty-one metatarsal bones have been removed, remodeled and reimplanted.

*Description of Operation.* From one to three bones can be operated upon at each sitting. The incision is made on the dorsum of the foot. If one bone is to be operated on the incision is over the shaft. If two are to be operated on, the skin incision may be made between the two. After the incision is made the tendons are released by gentle dissection and retracted. By deep pressure of the blunt end of an instrument the course of the metatarsal bone is determined. A deeper incision is then made down on the bone through periosteum throughout its whole length, and when the toe is reached, the incision is curved a little to one side, to avoid cutting the dorsal tendon going to the toe. The periosteum is then dissected from the metatarsal. The bone is osteotomized near the posterior end, using either a thin, narrow osteotome or, preferably, a small bone cutting forceps. The metatarsal bone is then grasped with a sharp pair of forceps and by rotating it right and left, the capsule is entirely cut loose at the metatarsophalangeal joint. The metatarsal bone is then removed. A little is cut off the posterior end of the removed part so that it will fit accurately in length when it is replaced and the dislocated toe dropped down into its normal position. It is reimplanted turned upside

down. When the bone is turned upside down, the bottom part of the anterior end, which is enlarged, is now the upper part, and this is cut off with bone cutting forceps. A small tibial graft is used as an intermedullary graft in pinning the bone ends together at the site of the osteotomy. The cavity in the sole of the foot beneath the anterior ends of the metatarsals is closed by sutures.

It is often advisable to arthrodesse the first interphalangeal joint of the toe. The operation makes it possible to relieve two extremely painful disturbances of the metatarsal part of the human foot—extreme hallux valgus and metatarsal equinus, and the affliction that is associated with walking and weight bearing with and without dislocation of the toes. Experience suggests also that this is a method of relieving the disabilities resulting from fractures and crush injuries of the anterior part of the foot that have healed in a way to produce pressure-pain from weight bearing.

#### MARCH FOOT

March foot is a subacute painful affection of the forepart of the foot, occurring chiefly about the shafts of the metatarsals and the surrounding soft parts. It develops insidiously with slowly increasing pain, which at first arises after prolonged excessive effort, later after ordinary exercise, and ultimately becomes continuous and incapacitates its victim.

March foot is often associated with an insidious spontaneous fracture of one of the metatarsal bones. According to Speed and Blake, the condition has been recognized for many years, especially by foreign military surgeons, who frequently encountered it among their troops after strenuous duties or long marches.

The history and clinical appearance are typical. A soldier after a long march, or a civilian who has been subjected to excessive foot strain, complains of pain in the forefoot and tenderness over the anterior portion of the second or third metatarsal bones. This is not sufficient to disable him

and he continues with his duties only to have the disability increase. After a few days a swelling is noticed involving the dorsal surface of the forefoot. The condition improves with rest, but resumption of activity aggravates the lesion.

Dodd believes that march foot is an "autotraumatic" complication of subacute flat foot occurring in architecturally weak feet. Muscular spasm and fatigue alternate, and as the latter supervenes the ligaments of the foot are gradually stretched, permitting direct trauma to the bony skeleton of the foot. These shocks affect the weakest bones first, i.e., the slender, resilient metatarsals. The second metatarsal is most commonly affected, then the third.

The majority of cases occur in soldiers carrying full packs on active service although civilians engaged in similar heavy occupations are affected. Women with arduous standing and weight-carrying work (waitresses, shop assistants and nurses) also develop the condition. Narvi believes that overloading causes stasis and thrombosis in the soft parts surrounding the bone and thereby interferes with the nutrition of the periosteum. The consequent swelling can be observed clinically as a painful mass on the dorsum of the foot and on the tibia. The roentgenograms of the metatarsal bones reveal a fracture line. The tibia first shows fissures penetrating deeply into the bone and an opacity of the bone structure; later, a callus formation and an induration of the bone appear.

Speed and Blake obtained complete series of roentgenograms in several cases, starting before there was any evidence of bone changes and following them through the various stages of early periosteal proliferation, the appearance of the fracture line, the formation of excessive callus, the healing of the fracture with contraction of the callus and eventual restoration of the apparently normal bone. The normal sequence of changes shown by the roentgenograms are as follows: (1) If taken very soon after onset of symptoms, the bones will be found to be entirely normal and

only swelling of soft tissues will be noted. (2) After one to three weeks there will be a little periosteal fuzziness at the site of the beginning fracture; very close observation may show a minute line of fracture. Occasionally the fracture appears before the periosteal reaction is seen. (3) A little later the periosteal shadow becomes more distinct and circumscribed and it will be noted that this callus is overabundant for the size of the bone involved and the size of the fracture. At this time the fracture usually can be seen distinctly and it will be found to have an irregular outline. (4) The fracture next shows signs of union. The callus is more dense and well circumscribed into a spindle shape. At this stage and in the preceding one, this condition has been mistaken for sarcoma which it simulates to some extent. (5) Films taken six months later will show solid union with absorption of the excess callus. The shaft will appear normal except for a small amount of residual cortical thickening.

The differential diagnoses suggested by Dodd are subacute flat foot, tenosynovitis, spasm of muscles, periostitis, synovitis, arthritis, rheumatism and finally fracture with callus formation. Recognition of the prodromal symptoms before fracture has occurred, is important, according to Speed and Blake because at this time the production of the fracture may be prevented by proper prophylactic measures. With rest, hot applications and relief from weight bearing, the condition may be arrested during the stage of preliminary swelling and the foot return to normal after a week or ten days. Toe exercises to restore the flexibility of the anterior metatarsal arch and a proper arch support or strapping of the forefoot should be employed when walking is resumed. For those patients who cannot comply with the period of complete rest because of economic reasons, strapping of the forefoot gives the most relief. The average disability, where fracture has occurred, is from four to eight weeks. Although suffering varying degrees of pain, very few patients will give up their work

but will continue to limp about, satisfied with the partial relief afforded by the strapping and arch supports.

Treatment recommended by Dodd consists in rest in bed until the pain and edema subside, with complete immobilization of the foot or feet by plaster, which is applied to maintain a dorsiflexed and an inverted position with a well moulded arch. If necessary, manipulation of the feet under anesthesia into this overcorrected position is advisable. With the subsidence of pain, patients get up and are carefully fitted with heavy shoes or boots which adequately support the feet. This footwear is adjusted with inside wedges to the heel and sole, metatarsal bars, or even an outside iron with an inside r-strap, if necessary.

#### JUVENILE DEFORMING METATARSOPHALANGEAL OSTEOCHONDRITIS

##### (Freiberg's Infraction of the Metatarsal Head)

This lesion was first described by Freiberg in 1913. He saw his first case in 1903, but his paper reporting six cases did not appear until 1914. Köhler described the condition in 1915, and in 1920 reported five cases. The number of cases reported to date is sixty-three. The two cases reported by myself bring the total number to sixty-five. The condition is much more common than I formerly believed, and I have seen at least twenty cases. Skillern called it an "egg-shell" fracture. On the assumption that it is analogous to similar conditions in other regions, especially in the hip, I added the terms metatarsal epiphysitis, metatarsal "flat-head" or osteochondritis deformans metatarso-juvenilis. A more descriptive term is juvenile deforming metatarsophalangeal osteochondritis.

I believe the etiology is similar to that of Legg-Calvé-Perthes, disease, Osgood-Schlatter's disease, Köhler's disease of the tarsal scaphoid, calcaneal apophysitis and Scheuermann's vertebral epiphysitis, all of which may be due to trauma affecting

bone and cartilage during a period of unusual growth. The important factors are: (1) trauma; (2) circulation; and (3) infection.

Freiberg believes that trauma is the cause, and states the mechanism of the injury as follows: Under normal circumstances, the second metatarsal bone is slightly longer than the first. In the presence of diminished power of toe flexion, especially of the great toe, the forcible impact of the ball of the foot against the ground, not sufficiently guarded by the flexor power of the toes, will cause the distal end of the second metatarsal to bear the brunt of the blow. All of his six reported cases were due to trauma, especially while playing tennis. Campbell emphasizes that sudden jumping on the ball of the foot with the toes dorsiflexed throws the heads of the metatarsals downward. He finds basketball, tennis and running upstairs to be the chief causes. Two of Painter's cases were due to baseball injuries. Skillern's patient merely stubbed her toe.

Alberti offers the following explanation: The second toe is longer than the others, and the head of the second metatarsal is the chief support of the foot; therefore it is subject to greater trauma. He is of the opinion that the lesion is first an osteochondritis, and then a chronic arthritis.

Axhausen is opposed to the theory of a traumatic origin, and believes that the lesion is due to an embolic obstruction of the corresponding epiphyseal and end-artery by tuberculous fragments or fragments with weakly virulent pyogenic cocci. The distal thickening of the shaft is explained by simultaneous emboli in the metaphyseal arterial branches, as a result of which inflammation of the bone develops. The local process with secondary arthritis deformans is similar to the formation of free osteocartilaginous bodies with secondary arthritis deformans in the other joints in which a traumatic etiology has been established.

It occurs especially during adolescence. Union of the metatarsal diaphysis and

epiphysis occurs between the eighteenth and twentieth years, and of the phalangeal structures, about the eighteenth year. It is possible that in the adult patients, the condition was present but unrecognized earlier.

All of Freiberg's cases were unilateral. One of Fischer's cases was bilateral. One of Campbell's cases was bilateral, affecting the third toe of the left, and the second toe of the right foot. All of Freiberg's six cases were of the second metatarsal. In one of Campbell's patients the third metatarsal was affected.

*Pathology, Embryology and Anatomy.* The metatarsal bones are each ossified from two centers; one for the body and one for the head, of the second, third, fourth and fifth metatarsals. The first metatarsal has one center for the body and one for its base. Ossification begins in the center of the body.

The gross pathologic changes consist of flattening of the metatarsal head, with broadening of the neck and distal portion of the shaft and irregularity of the epiphyseal line. In three of Freiberg's cases there were loose bodies.

Axhausen found, on histologic study of two resected specimens, an epiphyseal wedge-shaped necrosis with corresponding reparative processes. Under local anesthesia, Unger resected the metatarsal head in one case. He found the head split, the joint capsule dense, the epiphysis soft and the marrow reddish gray. Valentin's case showed microscopically that the cartilage and, in some places, the perichondrium were rich in cells. There were no marked signs of inflammation. In the metatarsal head that Campbell resected, no degenerative changes were found.

*Symptoms and Roentgen Ray Findings.* There is a uniform complaint of pain referred to the region of the affected metatarsal head. Swelling is usually present. It is due to exudate. No marked increase of joint tension is demonstrable. There is sharply circumscribed sensitiveness to pressure over the metatarsal head and the metatarsophalangeal joint. Abnormal local temperature is unusual. Definite limitation

of motion with muscle spasm is present. Abscess formation has not occurred in the cases reported.

To the Roentgen ray must go the credit for recognition of this condition. The findings are characteristic. They are: (1) flattening of the metatarsal head; (2) broadening of the neck and distal portion of the shaft; (3) irregularity of the epiphyseal line; (4) widening of the metatarsophalangeal joint space; (5) diminished cupping of articular surface of proximal phalanx; and (6) occasional line of incomplete fracture without displacement. Valentin, Axhausen and Liek found areas of sequestration similar to those observed in both cases of my report. In view of the fact that metatarsalgia is relatively uncommon in childhood, it is advisable to have roentgenograms made of both feet of every child who has a persistent metatarsalgia. It is possible that the first film will be negative and that the examination should be repeated. Occasional roentgenograms should be made of proved cases in order to check up on the progress of the condition.

The differential diagnosis rests between Morton's metatarsalgia, Deutschlander's metatarsal periostitis, fracture, dislocation, syphilis and arthritis of childhood, viz., Poncet's or Still's disease. In the condition described by Deutschlander, there is local tenderness at the junction of the middle and distal thirds of the metatarsal shaft, and Roentgen ray examination reveals evidence of periostitis. It is a subacute inflammatory periostitis.

If recognized early, and if proper treatment is instituted, the prognosis is excellent.

The course is short, lasting a few weeks. Recurrences have occurred after non-operative treatment, and all the cases in which operation has been performed are reported as cured.

*Treatment.* The treatment consists of absolute relief of the affected foot from weight bearing by means of crutches and a block under the heel and sole of the shoe of the opposite foot. The foot should be



immobilized in a plaster cast with a small, beveled felt pad applied just back of the metatarsal heads. As the cast sets, pressure is applied to build up the metatarsal arch.

When all symptoms have disappeared, a proper shoe is prescribed. This should be a straight last, round toe, medium shank shoe into which is inserted a felt pad for the transverse arch.

A metatarsal bar may be used, and the entire leather heel should be removed and a low rubber heel applied. A duralumin or other metal plate made over a corrected plaster cast may be used temporarily. Physical therapy, heliotherapy, hyperemia and hydrotherapy are indicated after the cast is removed. Baking, gentle massage and passive and active movements with contrast baths hasten recovery. Special exercises for the metatarsal arch are performed over a round doorstep screwed to a board. In cases in which the roentgenogram shows loose bodies, arthrotomy is advised.

#### AN AID TO CERTAIN STATIC FOOT CONDITIONS

As a supplement to my several articles on static foot conditions, especially the one that appeared in the *Journal of Bone and Joint Surgery*, July, 1930, I am presenting a modification of shoes that has a distinct value in a large group of static foot and ankle complaints.

Every orthopedic surgeon has used the original types or has modified them himself.

Sir Robert Jones describes the Crooks long heel and the bar behind the metatarsal tread. He said, "A simple and easy way of relieving the nerve from the pressure from the descended metatarsal head is by putting a leather bar  $\frac{1}{2}$  inch or  $\frac{3}{4}$  inch broad across the sole of the boot behind the heads of the metatarsals. As the patient walks, the sole in front of the bar becomes displaced, making a countersunk hollow in the sole so the pressure on the heads of the metatarsal is removed."

The bar was first put on the outside of the sole of the shoe, between the layers of the sole, and finally brought to the outside

again. When it is placed between the layers of the sole it acts as a rocker.

The modification which I wish to elaborate on is not my design but the outgrowth of many attempts by various writers. It is a distinct improvement over the combination of the Thomas heel and outer sole wedge or the metatarsal cleat or crescent.

In *Surgical Clinics of North America* (February, 1938), Hauser states, "Case 1. A corrective shoe was prescribed with the heel supinated  $\frac{1}{2}$  inch and a comma-shaped transverse bar was raised  $\frac{1}{4}$  inch on the outside. The bar extended from behind the head of the 4th metatarsal across the first metatarsal, with an inclined plane directed toward the first metatarsal. . . . Case 11. The heel was supinated  $\frac{1}{6}$  inch and the comma shaped transverse bar was raised  $\frac{1}{4}$  inch on the outer side. . . . Case IV. He was fitted with satisfactory shoes and the usual corrections for pes valgoplanus were carried out. This means a supination heel and pronation of the transverse bar." So far as I know there has been no further description of or any illustration of this modification of shoes.

The objective of many clinicians has been: (1) to supinate the heel and (2) to pronate the forefoot. This can be accomplished by a triad of changes in the ordinary shoes: (1) removal of the metal shank, if present; (2) application of a Thomas heel; and (3) application of a metatarsal comma bar.

When all changes have been made, the shoe must be in perfect balance.

1. The initial bearing surface is indicated (1) on the back of the heel. (Fig. 6.)

2. From (1) the weight is carried to the anteromedial point of the heel.

3. From (2) the weight is shifted to (3) which is the high point on the lateral border of the metatarsal comma bar.

4. From (3) the weight is thrust on (4) which is the low point on the medial border of the metatarsal comma, just back of the big toe joint.

By this progression "foot rhythm" is restored because it supinates the heel and

pronates the forefoot. The "push off" in walking occurs at the big toe joint. (Observe a sprinter for example.)

These modifications fulfill the requirements set up by many orthopedic surgeons and so properly emphasized by Michael Hoke that the three most important muscles and tendons of the foot are given the opportunity, or are compelled to function at their optimum efficiency, viz., anterior tibial; peroneus longus; flexor hallucis longus.

The "comma" may be made of leather or rubber or a combination of both. It may be level or higher laterally or medially, depending upon the individual problem.

Variations of this system may be made as follows:

1. Metatarsal comma bar to correct varus.\*

\*After this article had been completed, a paper appeared in the *Surgical Clinics of North America*, February, 1939, in which Hauser discussed muscle imbalance of the foot and presented an illustration of the combination modified heel and the metatarsal comma bar with brief instructions as to measurements.

2. Metatarsal comma bar to correct valgus.

3. Metatarsal comma bar to shift weight toward the big toe joint.

4. Metatarsal comma bar to shift weight away from the big toe joint.

In cases of pain in the big toe joint or sesamoiditis the metatarsal comma must be modified to remove pressure from the big toe.

A modified heel and a metatarsal bar can be used with a rigid shank shoe but a rigid shank cannot be used in conjunction with a metatarsal inverted comma.

The patient may alternate with a rigid shank shoe with a metatarsal cleat or crescent.

There are several flexible shank shoes on the market which avoid the necessity of removing the steel shanks of the ordinary shoes.

A large percentage of static foot conditions can be relieved by these modifications.



# HAMMER TOE

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**H**AMMER toe, with the corn-like bursa on its dorsal apex rasping against the toe cap of the shoe and the calloused top of the digit cramped against the sole, is a disability often of greater proportion than such an apparently insignificant deformity would seem to impart. Usually the second toe is affected. The characteristic flexion contracture of the proximal interphalangeal joint more frequently is of congenital origin, but may be acquired through injury or through abuse of the feet by improperly fitted shoes. Clawfoot contracture of the foot in which all the toes are cramped into acute flexion can hardly be classified with hammer toe, nor is the treatment the same. In the typical congenital hammer toe deformity the lateral ligaments and the glenoid ligament are rigidly contracted so that neither tenotomy nor forcible stretching is of permanent benefit, while in the flexed toes of a clawfoot, tenotomies and metatarsal excisions usually result in satisfactory correction.

The short muscles of the digital phalanges of the foot do not have quite the same unique action as those of the hand. The lumbricales of the hand extend the second and third phalanges as well as flex the first phalanges, while in the toes they flex the first phalanges only. Likewise, the interossei plantaris and dorsales flex the first phalanx only. Contraction of the flexor digitorum longus or brevis will result in acute flexion of the proximal interpha-

langeal joint and a corresponding dorsiflexion of the metatarsophalangeal joint. Likewise, any binding of the extensor digitorum tendon to the proximal interphalangeal joint such as might occur from injury or bursitis would promote flexion of this joint with dorsiflexion of the metatarsophalangeal joint so that a typical hammer toe deformity would thus be created.

*Treatment.* The only successful treatment of the typical hammer toe is excision of the proximal interphalangeal joint. Amputation is a serious error because it will permit hallux valgus of the big toe and thereby increase disability. Tenotomy and splinting may temporarily correct the deformity, but relapse is almost certain to occur. In the very young an exception may be allowed to this statement, but even here, excision is found to be preferable to temporizing with inadequate procedures.

The operation consists of excising the corn-like bursa by an oval incision and then excising the articular margins of both phalanges sufficiently to permit the toe to straighten easily. The flexor tendon should be divided as it is of no further use. After suturing so that the excised ends of the bones are closely approximated, the toe is splinted in extension. In ten days the patient can resume the use of a shoe over the splinted toe. It requires about six weeks for union to occur sufficiently to protect against relapse.



# SURGICAL TREATMENT OF HALLUX VALGUS BUNION

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THE characteristic hallux valgus deformity of the great toe, commonly termed "bunion," is an unsightly, exasperating disability of the foot, often tolerated for years by the sufferer because of fear of surgical correction. There seems to be a universal idea that an operation will cause the toe to be stiff or useless. It is quite likely that this general apprehension is due to the occasional disastrous results in improperly selected cases and the long period of disability following such procedures as resection of the metatarsal head or osteotomy fractures of the shaft of the metatarsal.

Since more than fifty different procedures have been described it is quite indicative that satisfaction in surgical technique is difficult to obtain. A successful operative procedure is one that fulfils not only the surgical requirements in correcting deformity, but also the patient's expectations in respect to early return of function, relief of pain, and cosmetic improvement.

A technique previously described by the author\* to meet these requirements is one in which the correction is made by releasing the deforming forces directly at their point of contraction rather than by indirectly attacking the skeletal form for realignment.

*Pathologic Anatomy.* When the anatomy and mechanical peculiarities of the big toe are understood the measures for correction can be applied more directly. The relationship of the big toe to the remainder of the foot is similar to the relation of the thumb to the hand. Each is a structural unit individualized anatomically by an advantageous design of skeletal support and

equipped with a specialized mobilizing muscle and tendon system. The finer movements in the big toe are undeveloped, although highly perfected function may still be seen occasionally in natives of isolated areas or where congenital loss of the hands has induced substitution of the toes.

A distinctive feature of construction is that none of the muscles of propulsion is inserted in the first metatarsal shaft or head. The tendon action is referred entirely to the phalanges, whereas the metatarsal shaft with its free rounded head and its ligament bound base serves as a fulcrum to the toe action, and as an abutment to the weight-bearing forces transmitted from the keystone tarsals of the arch. Normally in the unshod foot there is an equilibrium between the abductor and adductor forces acting on the proximal phalanx of the big toe. The wearing of shoes, however, gives advantage to the adductors so that when bursal or articular disturbances arise, the resulting contraction produces a valgus of the toes. As the deformity progresses the transverse axis of the metatarsophalangeal joint becomes oblique and the tension of the extensors is added to that of the adductors to spread the head of the metatarsal medialward and the toe outward.

*Treatment.* The extent to which the deformity and pathologic changes have developed will determine the degree of surgical interference. The bursitis and arthritic changes may be severe or mild. The deformity of the toe may be very moderate, yet the pain and disability may be severe, or the deformity may be severe and the symptoms very mild. In children and young adults much may be done by proper measures of prevention, but when

\* McBRIDE, E. D. Conservative operation for bunions. *J. A. M. A.*, 105: 1164, 1935; *J. Bone & Joint Surg.*, 10: 735, 1928.

pathologic changes have arisen there is little to be expected from appliances or non-surgical measures.

The objectives toward which correction of the deformity must proceed are as follows:

1. Restore the transverse axis of the metatarsophalangeal joint and return the phalanges to their normal weight-bearing line.

2. Approximate the diverging head of the first metatarsal to the second metatarsal.

3. Permanently relieve the overwhelming stress of adductor tension to prevent relapse.

4. Remove the painful factors of bursitis, exostoses and sesamoid displacement.

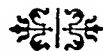
*Essentials of the Operation.* The conjoined tendon of the adductor hallucis and the lateral head of the flexor brevis is released from its attachment to the base of the proximal phalanx and transplanted into the lateral side of the first metatarsal head, using sutures that will draw the first and second metatarsals tightly together. Additional relaxation is obtained by removal of the lateral sesamoid which, in most instances, is demonstrated by x-ray to be displaced and acting as a levering wedge to force the first metatarsal head medialward. Both sesamoids should be removed if they are painful.

To accomplish this very tedious work the incision is started near the web on the lateral side of the first toe and extended upward and obliquely medialward along the extensor hallucis longus tendon. After the work is completed on the lateral side of the toe the skin and fascia are dissected and retracted from the medial rotundity

of the metatarsal head and joint, so as to expose thoroughly the bursa. The bursal fascia is cut transversely and dissected from the bone and a section removed to permit suturing it together later with tension enough to maintain the toe in slight abduction. When the phalanx has been restored to its transverse axis there is usually much less bone prominence than expected. No more bone is excised from the medial side of the head than is necessary to flatten the surface flush with the shaft of the metatarsal. Care must be used to leave no small spicules of bone or tags of periosteum. As few catgut knots as possible should be used and the wound should be dry before closing. A little time and compression after removal of the tourniquet will usually stop the oozing. During the closing process the toe should be kept in a little over-correction and a plaster spica applied over the toe and ball of the foot. The patient can bear weight in the plaster support about the seventh day. The plaster is changed to a spiral bandage and adhesive plaster support when the stitches are removed about the tenth day. The patient may then be permitted to walk in shoes by cutting an opening to allow for the corrected position of the toes.

#### SUMMARY

The deformity of hallux valgus can be satisfactorily corrected by releasing the adductor tension which is producing it. Such a procedure affords much quicker return to weight-bearing function than when the more radical procedures of bone resection or osteotomy are used.



# CUTANEOUS DISEASES OF THE EXTREMITIES AND THEIR RELATION TO SURGERY\*

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THERE is perhaps no specialized field of medicine that does not overlap to a limited extent some other field. It is only to be expected that certain diseases coming within the domain of the dermatologist should also be of surgical importance. While the majority of these might be treated similarly by both dermatologist and surgeon, there are some in which coöperation between the dermatologist and surgeon is conducive to the best therapeutic result. There are others in which treatment of the dermatosis may prevent complications which might require surgical intervention. It is not our purpose to consider in detail all the various diseases of the extremities that one might find described both in a text on minor surgery and a text on dermatology, but particularly to describe certain instances in which coöperation between the dermatologist and the surgeon has worked for the best interest of the patient.

A study of Foote and Livingston's "Principles and Practice of Minor Surgery" reveals at least thirty or more diseases of the extremities which one will find discussed also in the more extensive texts on dermatology. These are in the main as follows:

Burns	Felon	Eczema
Frostbite	Lymphangitis	Chronic ulcer of
Wound infections	Syphilis	the leg
Anatomic tubercle	Anthrax	Perforating ulcer
Erysipelas	Tularcemia	Madura foot
Erysipeloid	Sporotrichosis	Callus
Superficial boil	Ganglion	Corn
Carbuncle	Epithelioma	Wart
Paronychia	Sarcoma	Sebaceous cyst
Cellulitis	Melanoma	Scrofuloderma
		Lymphadenitis

To these may be added glomus tumor, nevus, fibroma durum, onychomycosis, and granuloma pyogenicum.

The surgical and dermatological management of several of these conditions, for example, burns, furuncles, carbuncles, felon, sporotrichosis and epithelioma is so entirely similar that any discussion in this paper seems unnecessary. In others the surgeon is interested in one phase of the disease, the dermatologist in another. For example, in frostbite the surgeon is chiefly interested when the question of amputation arises; the dermatologist is more interested in those recurrent chilblains that so often respond promptly to x-ray therapy and local dermatologic therapy. In our presentation we are chiefly interested in (1) those diseases in which collaboration between the dermatologist and surgeon is provocative of the best therapeutic result; and (2) those diseases which, treated by the dermatologist, may prevent the development of later complications which might result in the necessity of surgical intervention. It is the latter group that we wish particularly to discuss. However, there are some interesting points in connection with a few of the other diseases that are of common interest to the surgeon and dermatologist that we will briefly mention.

For example, *erysipeloid*, although usually a mild, localized cutaneous infection, may rarely be expressed as an acute septicemia with a fatal outcome, or as a generalized cutaneous infection with arthritic and constitutional symptoms. The surgeon is frequently consulted because of the confusion of *erysipeloid* with a pyo-

\* From the Department of Dermatology and Syphilology, Temple University School of Medicine, service of Dr. Carroll S. Wright.

genic infection and we wish to call attention to the extensive studies of Klauder<sup>1</sup> who points out that the most severe types

the internal administration of combined brewer's yeast and tin proteinate given over a period of time.



FIG. 1. Draining sinus from old shrapnel wound with streptococcic dermatitis of surrounding skin. (October 19, 1938.)

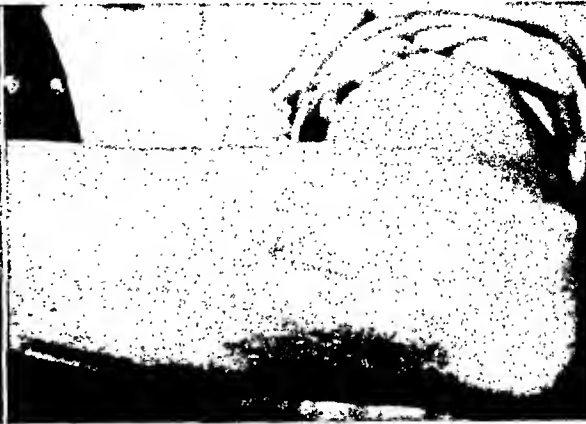


FIG. 2. Complete disappearance of skin lesion and healing of the old wound after administration of sulfanilamide. (November 5, 1938.)

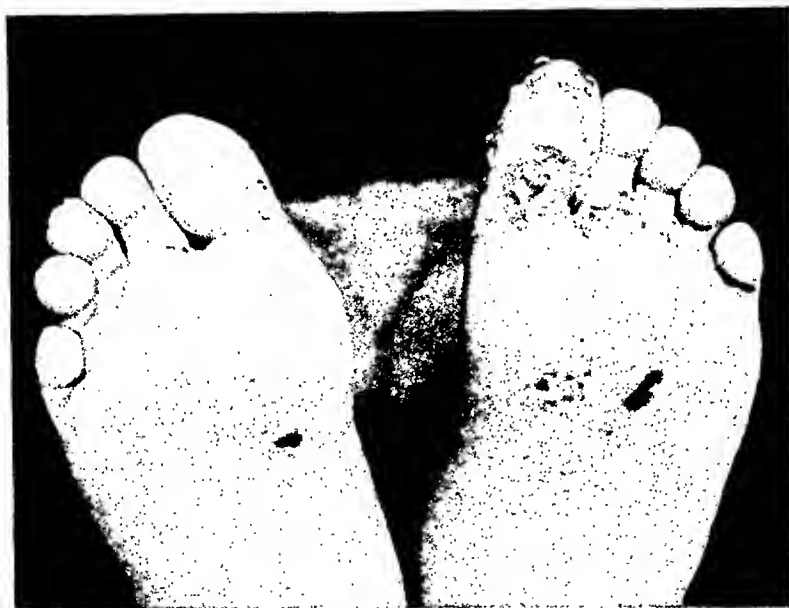


FIG. 3. Dermatophytosis of the feet. Secondary lymphangitis, lymphadenitis, cellulitis, phlebitis or erysipelas may follow.

of the infection are contracted from a fish source, and furthermore that the source of the infection is usually in the occupation of the patient. Although *lymphadenitis* and *lymphangitis* (which may at times be considered surgical) occur early, they disappear before the involved skin returns to normal and without surgical intervention.

Although furunculosis may require surgical attention, one of us (C. S. W.) has recently<sup>2</sup> pointed out that the majority of cases of chronic furunculosis respond to

As an example of a condition in which surgical and dermatological collaboration cured a stubborn wound infection we cite the following case (Figs. 1 and 2.)

CASE 1. I. M., a white man aged 39, sustained a shrapnel fracture of his left radius and ulna in 1917. After six operations the wound healed and remained healed for twenty years. About January, 1938 he developed sudden severe pain and swelling in the region of the wound scars. Several days later he was operated on and bone sequestra were removed. A



slightly draining osteosinus persisted. About October 1, 1938 the skin about the sinus orifice became red and painful and spread



FIG. 4. Chronic ulcer of the leg. Streptococci recovered from the discharge. Infection disappeared following administration of sulfanilamide.

peripherally. Three weeks later the skin of the upper two-fifths of the extensor surface of the left forearm presented an intensely acute dermatitis, the center of which was the discharging sinus orifice. (Fig. 2.) The patient complained of marked pain, intense itching, and inability to sleep.

Bacterial culture on blood agar revealed: Aerobic, hemolytic staphylococcus aureus (pure culture); Anaerobic, many hemolytic streptococci (pure culture).

Sulfanilamide, gr. 15, was administered every four hours for a total of 60 gr. the first day, 40 gr. the second and subsequent days. Within two days after starting the sulfanilamide the pain disappeared, itching ceased, the involved area became dry, scaly and pale, and the moisture at the sinus orifice became scanty. Within ten days healing of the skin and wound was complete.

Table 1 presents those conditions which primarily come to the attention of the der-

matologist but which may lead to complications that require surgical intervention.

TABLE I	
Dermatosis	Surgical Complication
Fungus diseases (hands and feet).....	{ Erysipelas
	{ Cellulitis
	{ Phlebitis
	{ Lymphangitis
Insect bites.....	{ Lymphadenitis
Eczema (varicose).....	{ Pyodermia
Plantar wart.....	{ Chronic ulcer
Nevus.....	{ Multiple warts
Syphilis.....	{ Ulceration (radiation)
	{ Melanotic carcinoma
	{ Periostitis
	{ Perforating ulcer
	{ Gummata

*Fungus Diseases.* Traub and Tolmach,<sup>3</sup> in 1937, reported eight cases in which an erysipelas-like eruption complicated a dermatophytosis and stated that there could be no doubt that fungi had produced the erysipelas-like eruption. McGlasson and Amoss had previously assumed that streptococci were the causative agents in recurrent erysipelas of the legs associated with infections of the feet. Later, in 1937, Sulzberger, Rostenberg and Goetze<sup>4</sup> also reported cases of recurrent erysipelas-like manifestations of the legs associated with fungus infections of the feet.

One of us (C. S. W.) saw in consultation with a surgeon a woman who had had within a period of a few months two successive attacks of phlebitis of one leg, but at the time of the consultation presented an erysipelas-like eruption of the same leg with a temperature of 103°F. Attention was called to interdigital fissuring and scaling of the foot and microscopic examination was positive for fungi. Following antiparasitic treatment of the foot with involution of the dermatophytosis there were no further attacks of phlebitis or erysipelas.

The authors (Fig. 3) have seen cellulitis, lymphangitis and lymphadenitis extend from or complicate a dermatophytosis. Incision of pustules and vesicles and the constant application of wet dressings to the feet invariably suffice to clear up all complications.

*Insect Bites.* Secondary infection of insect bites may result in ecthymatous

lesions producing superficial or moderately deep ulceration. Surgical intervention is rarely necessary as the infected lesions

on the anterior aspect of the middle of the left leg a large, longitudinal, sharply margined ulcer of roughly oval outline, measuring about



FIG. 5. Multiple plantar warts of feet. Patient had been treated with x-ray, strong salicylic acid and plasters. (Courtesy of Dr. John B. Flick.)

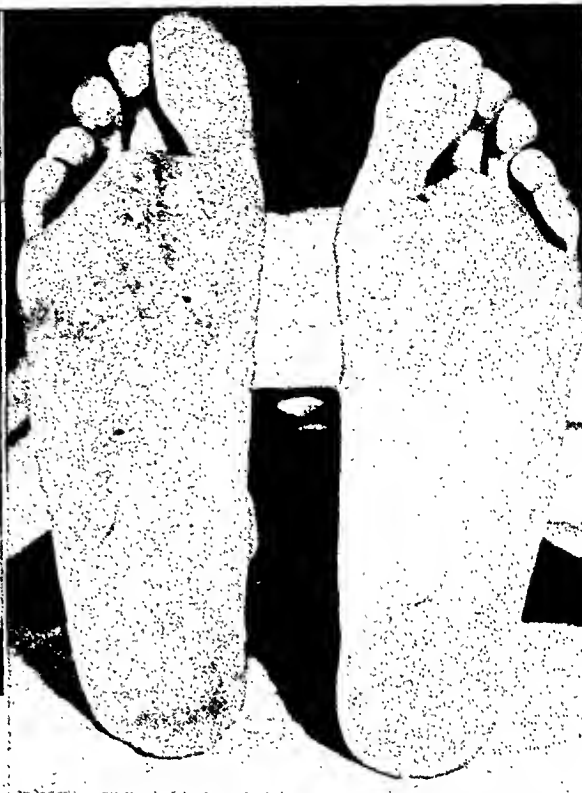


FIG. 6. Groups of warts removed surgically and areas covered with pedicle flaps. (Courtesy of Dr. John B. Flick.)

respond promptly to the application of ammoniated mercury.

**Eczema.** Eczema of the leg is of interest to the surgeon because it may precede or accompany a chronic ulcer. Ulceration may result from scratching a streptococcic infection or from breaking down of an underlying varicose vein. The following case (Fig. 4) presented at the October, 1938 meeting of the Philadelphia Dermatological Society by Dr. C. S. Wright and Dr. Reuben Friedman, is an example of a *chronic streptococcic ulcer of the leg responding to sulfanilamide*, as suggested by Goodman.<sup>3</sup>

**CASE 11.** J. V., a white man aged 82, about eight years previously had excoriated a "pimple" on the anterior aspect of the left leg until it became raw and bleeding. A progressive ulceration developed which, despite all therapy, never healed. On first examination there was

11 × 5.5 cm. in diameter. Near the upper posterior border there was some well-marked undermining of the edges. Pressure resulted in the exudation of serous, yellow-brownish fluid. The floor of the ulcer was covered by heaped up, irregular masses of smooth, shining, granulation tissue bathed in thin, serous exudate, and also showed two small patches of yellow-green necrotic tissue. Most of the margin of the ulcer was merged with the surrounding skin without any undermining of the edge, except as previously noted. The skin for about 4 or 5 cm. around the ulcerated area was violaceous red in color, shiny, thickened, and here and there painful on pressure.

Blood serologic tests were repeatedly negative. Bacterial culture on blood agar showed: aerobic—overgrown with a contaminated growth of *B. subtilis*; anaerobic—pure culture of hemolytic streptococcus.

The patient was given sulfanilamide, gr. 15, every four hours with marked improvement within two days. The necrotic patches were smaller and drying up. Granulation tissue

appeared healthier. There was little or no seropurulent exudate present. The undermined edges fused with the base of the ulcer. The

Case 111 (Fig. 5) was seen by one of us (C. S. W.) in consultation with a surgeon and a radiologist. Radiation therapy had

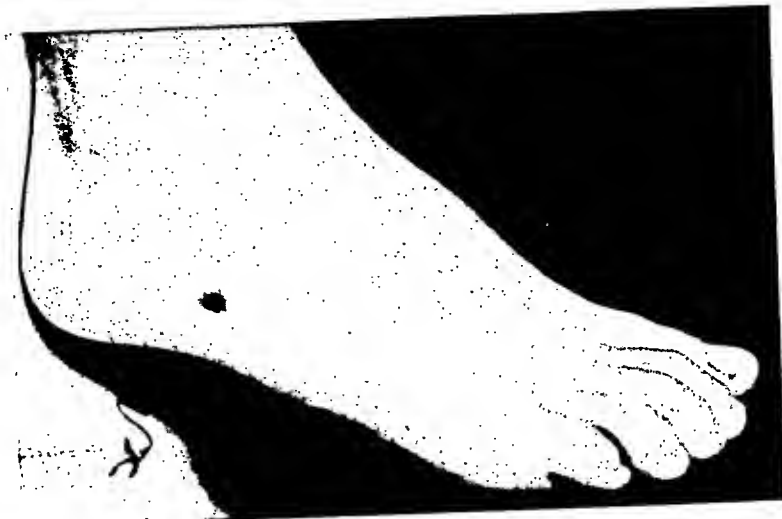


FIG. 7. Blue black nevus. Imperfect removal or trauma may result in melanocarcinoma.

surrounding skin became paler and there was no more tenderness about the ulcer. Because of the extensive loss of skin, skin grafting by the surgical department was recommended.

*Prompt treatment of an itching eczema of the leg or an infection, no matter how slight, may prevent the development of an ulcer.*

**Plantar Warts.** These are by no means rare and in the majority of cases are of infectious origin. Radium and Roentgen therapy is used with frequent success, but at times warts are radioresistant and excessive irradiation may be harmful. If the wart has not entirely disappeared after six weeks of moderate irradiation, Blair, Brown and Byars<sup>6</sup> advise either knife excision and immediate suture or accurately limited cautery destruction. They also recommend that a cornlike scar, following primary wart destruction, be completely excised and the defect if small be closed by skin suture. For larger defects, a pedicle flap including skin and part thickness of pad can be switched from a nonweight-bearing surface of the sole, either of the front of the ball just behind the toes or of the inner half of the central part, and the resulting defect in this area may be covered by a skin graft.

not influenced the growths which spread rapidly until the patient could scarcely walk. Surgical excision and pedicle flaps were recommended, with the result pictured in Figure 6. A few new warts have since appeared and were removed immediately by electrodesiccation under local anesthesia.

**Nevi.** The dermatologist is the one whose advice is commonly sought regarding the treatment of nevi of the extremities. These are chiefly of significance because of the danger of melanocarcinoma. Melanocarcinoma may have its origin in any mole containing nevus cells but more commonly from the black or bluish black moles.

Because trauma may result in such moles undergoing malignant change, it is usually best to remove them surgically with wide extirpation. The tissue is examined microscopically to determine that all pigmentation is removed. As pointed out by Andrews,<sup>7</sup> "If the extirpation is not sufficiently wide, not only has pathologic tissue been left in situ, but also more harm than good may have been done by opening channels of metastasis into subepidermal layers or into the lymphatic nodes of adjacent regions."

*Syphilis.* Although the late lesions of syphilis commonly involve the extremities, the manifestations rarely have any particular surgical significance if the true nature of the disease is recognized. In the following case, surgical amputation of the foot was recommended by a surgeon but was avoided when the lesions disappeared under treatment with neoarsphenamine.

CASE III. K. A., a white woman, aged 65, developed a fungating growth of the sole following removal of a callus by a chiropodist. The lesion increased in size until the entire foot was deformed and showed multiple nodular and fungating lesions, accompanied by marked pain. The patient gave a history of having received antisyphilitic therapy, chiefly mercury, many years previously. In spite of a negative Wassermann reaction, bismuth salicylate was injected weekly in 2 Gm. doses for three months. The lesions continued to increase in size and number. Several dermatologists who saw the patient were unable to agree upon a diagnosis and a surgeon recommended amputation. In spite of the patient's age an intravenous injection of neoarsphenamine, 0.1 Gm., was given, following which the pain diminished and the lesions gave evidence of beginning involution. After eight weekly injections the foot was entirely normal.

#### COMMENT

We have presented but a few examples of conditions in which the dermatologist and surgeon have a common interest. We have attempted to show that numerous diseases of the extremities come within the scope of both the dermatologist and the surgeon. Our chief aim has been to indicate that dermatologic therapy properly applied to numerous cutaneous diseases may prevent surgical complications, and that in others the dermatologist should immediately step out of the picture and the surgeon step in.

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# CHIROPODIAL CLASSIFICATION AND TREATMENT OF EPIDERMAL EXCRESCENCES\*

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## CALLOSITY

*Synonyms.* Callus; tylosis; callositas.

*Definition.* A callosity is a thickening of the epidermis usually found on the plantar surface of the foot and palmar surface of the hand.

*Etiology.* A callosity is the result of some form of mechanical irritation, such as standing or walking in improper footwear. The growth develops primarily as a protection to the delicate structures beneath the skin. It may also result from certain chronic skin diseases, such as eczema, psoriasis, etc. A depressed metatarsal arch is a frequent cause of callus on the ball of the foot.

*Pathology.* The growth consists of thickened epidermis with the dermis not involved. There is little or no inflammation present unless it is secondary to an injury or infection. The overgrowth may continue to a great extent and frequently helomata develop within the callous.

*Symptoms.* The lesions appear as variously sized areas of thickened epidermis of

grayish or yellowish color. They are usually thicker at the point of greatest pressure, and gradually shade off into the normal skin.

The patient does not experience as much pain from a callosity as from a heloma. The pain produced by callosities is usually of a burning character.

*Treatment.* After sterilization of hands, instruments, and field of operation, the thickened epidermis is removed with a wide chisel or scalpel. Care should be taken when paring these thickened surfaces not to cut away too much of the callous tissue, as otherwise the patient will experience pain in walking. A shield of felt or moleskin is placed on the part to ward off pressure. If the callus has been caused by displacement of a bone, this must be taken care of with the proper corrective treatment.

## HELOMA

*Synonyms.* Corn; clavus; tyloma.

*Definition.* A heloma is a circumscribed overgrowth of epidermis with a central core which presses upon the corium.

\* Authors' Note: In common with other recognized branches of medicine, chiropody struggled through years of "Preceptor" training and the slow growth of educational and economic expediency in its institutions, without, however, having once lost sight of a goal to make of its calling an ethical pursuit of a branch of medicine. Not as a "cult" did chiropody develop, but as a definite unit of medically trained students with known obligations toward its parent body as well as cognizance of its specialty of practice. This, today, is evident in its well controlled institutions of learning, numbering six in the United States, among which is the School of Chiropody in Temple University. Over a period of twenty years chiropody has attained a remarkable scholastic growth, four full years of teaching and clinical practice leading to the academically accepted degree of Doctor of Surgical Chiropody (D.S.C.). Forty-five of the forty-eight states have recognized chiropody as a medical pursuit through the establishment of State Boards of Examiners composed of physicians or chiropodists or jointly ruled by both professions.

Research being a requirement for classification of a school by the Council on Education of the National Association of Chiropodists, the contributions of the profession of Chiropody should, in the future, provide for the medical world findings of primary importance. At the present date there are research projects under way in the various schools to include: (1) the etiologic factors in the production of callus; (2) the incidence of trichophyton infection in the chemotherapeutic action of various antiseptics; (3) the bacteriology of verruca—the possibility of filtrable virus infection; (4) fungus infections; (5) rubber compounds as substitutes for felt dressings; (6) the use of non-corrosive light weight materials for foot appliances; (7) the significance of shortened calf muscles in chiropody; (8) treatment of heloma by electricity; (9) practical tests in orthodigita; (10) cause and treatment of hallux valgus; (11) relationship of weight-bearing to foot disability; (12) chemical and medicinal treatment of verruca; (13) the use of rubber in the treatment of ulcers; and (14) the use of mecholyl by iontophoresis in circulatory disturbance of the lower extremities.

*Size and Shape.* They vary in size from that of a pin head to that of a pebble, and are usually conical in shape with base upward and outward, and apex pressing downward and inward.

*Classification.* Helomas are classified according to their appearance, texture, or composition:

1. Heloma durum—hard corn.
2. Heloma molle—soft corn.
3. Heloma miliare—seed corn.
4. Heloma vasculare—vascular corn.
5. Heloma neurofibrosum—corn containing nerve endings.

*Formation of a Heloma.* 1. There is an excitation of the cutaneous nerves caused by pressure and friction.

2. This causes an increased blood supply and the dermis immediately beneath becomes congested.

3. The congestion causes a more or less permanent enlargement of the papillae.

4. With the enlargement of the papillae, there is a greater amount of nutrition supplied to this area.

5. Increased nutrition causes increased cell production.

6. Excessive development of cells causes an abnormal upward crowding of these cells.

7. This causes the upper layer of the epidermis to become thickened.

8. This thickened horny layer acts as a counter-pressure and cornification or hardening of the tender cells takes place more rapidly as each succeeding new layer is added to the under portion of that already formed.

9. This causes the epidermis to become transformed into a dense, homogenous mass of cells constituting a callosity the size of which is determined by the area of the papillae involved.

10. As the factors which have produced this condition are continued, that portion which was formed earliest gradually becomes thicker than the rest and thus more pressure is subjected to it.

11. The denser portion, known as a core or nucleus, extends downward and presses upon the dermis.

12. Increased pressure on the dermis causes an atrophy of the papillae directly under the nucleus.

13. With atrophy of the papillae, the growth is now dependent upon the increased vascularity surrounding it. Therefore, the growth takes place on its lateral portions mainly and increases its diameter.

#### HELOMA DURUM

*Synonym.* Hard corn.

*Definition.* A heloma durum is a hard circumscribed overgrowth of epidermis usually found on the outer side of the fifth toe, the dorsum of the three middle toes, the great toe joint, and the plantar area of the foot.

*Etiology.* Helomata result from pressure and friction. This may be caused by the following:

1. Ill-fitting shoes and stockings

(a) Short shoes and stockings will cause:

Heloma durum on dorsum of toe

Heloma durum on distal end of toe

Heloma durum on plantar surface under metatarsal heads

Heloma Durum on medial aspect of the first metatarsophalangeal joint

- (b) Narrow shoes will cause:

Heloma durum on fifth toe

Heloma durum on first metatarsophalangeal joint

Deformity of the three middle toes with resultant heloma durum on dorsum or distally

- (c) Too large shoes or stockings will cause:

Heloma durum on posterior aspect of heel

Heloma durum on dorsum of foot

2. Lack of protection from a thin sole or a worn out sole

3. Seams in the sole or toe of stocking

4. Foreign bodies: nails in shoe; sand, hair, wrinkled inner sole

5. Unsuitable materials for foot covering: patent leather, cordovan, snake skin, Scotch grains, crepe rubber sole

6. Deformity or displacement of the bony structures—

- (a) Downward displacement of one or more metatarsal heads
- (b) Exostosis formation, particularly at the head of the first metatarsal, and on the dorsum of the foot
- (c) Malalignment of the interphalangeal joints

*Pathology.* Helomata are an overgrowth of closely packed epidermal cells arranged in concentric layers. This hypertrophy of tissue usually assumes a conical shape, the base external and outward, the apex directed downward upon the papillary layer of the dermis. The papillae directly beneath the apex become atrophied. There is a more or less hypertrophy of the papillae at the circumference of the heloma. The sudoriferous glands involved do not atrophy.

*Symptoms.* The patient complains of pain which may vary in character from an uncomfortable feeling noticed only when the shoe presses on the lesion, to a constant throbbing sensation of which the patient is conscious whether the shoe is off or on. The patient will frequently describe the latter condition as a "toothache of the foot." Climatic changes, such as rain or snow, seem to intensify the pain ordinarily existing in and about a heloma durum. This is due to the fact that the horny material which makes up the corn is hygroscopic and tends to become swollen when the air is moist.

The heloma presents a horny overgrowth of epithelial cells of slightly yellow color. A darker, more compact mass appears in the growth, called a nucleus. The skin surrounding the heloma is usually congested, and heat, redness and swelling may be observed.

*Treatment.* *Palliative treatment*, i.e., any method of treating helomata non-operatively, consists in the use of chemical agents which desiccate the growth. The agent

usually employed is salicylic acid in the form of 25 per cent ointment, which is placed in the aperture of a shield and allowed to remain on the corn for two to three days. When the dressing is removed, the skin appears white and soft. This soft tissue is peeled off the toe. The procedure is repeated until the entire growth is removed.

The application of salicylic acid preparations which, of course, includes all commercial "corn cures," is rather dangerous as the action of the chemicals is hard to control, and in many cases is the cause of severely inflamed or infected toes. This is due to the fact that salicylic acid will not differentiate between epidermis and dermis, but attacks both these layers of the skin.

A patient who has administered home treatment of "corn cures" will often find his way to a chiropodist's office with a very troublesome toe. A blanched appearance is noted superficially, with acute inflammation underneath, and there is often infection.

Treatment of these "corn cure" cases should be conducted along the following lines: (a) sterilization of the hands, instruments and field of operation; (b) removal of as much indurated tissue as possible without creating a hemorrhage; and (c) if acute inflammation or infection is present, application of a wet dressing. If the toe is only mildly inflamed, a suitable pad containing an ointment such as 10 per cent ichthyol or 10 per cent boric acid may be applied.

*Operative Treatment.* This is the usual chiropodial procedure for the removal of helomata. After sterilization of instruments, proper cleansing of the hands and field of operation, there are three methods or techniques for the removal of these conditions:

1. Complete Dissection. In this technique the entire growth is removed "en masse," a single piece. The cutting instrument, either chisel or knife, is held in the right hand and the thumb forceps in the left, each being held as one would a pencil.



To support and steady the hands, one may let them rest gently on the fourth and fifth fingers. When operating between the toes, the fingers may rest upon and press aside the toes so as to give ample room for operating. The cutting instrument is held in the same plane (flat to the skin surface) as the heloma, and a flap cut is made at the margin of the formation, with care to avoid hemorrhage. With the thumb forceps, the free edge is grasped and raised sufficiently to see the "line of demarcation." The "line of demarcation" is made by the union of the light and dark shades of tissue, the normal being light and the darker belonging to the heloma.

Just enough traction or lift is used on the forceps to overcome the pressure of the cutting instrument, not enough, however, to produce the sensation of pulling. The "line of demarcation" is carefully followed until the entire lesion is removed. When properly performed, the gentle lifting of the excrescence prevents the sensitive tissue underlying the heloma from being pressed upon by the blade of the instrument.

This technique is not an advisable one for the beginner. While it is quicker, more professional and easier on the cutting edges of the instruments, at the same time it is more painful for the patient, more difficult to perform, hemorrhage is more frequent and severe.

2. *Partial Dissection.* In this method, which is a combination of the preceding and following techniques, the heloma is reduced in size by cutting off the topmost layers in small sections and dissecting out the deeper section (nucleus) in one piece. Again, one holds the cutting instrument like a pencil. The skin surrounding the heloma is held taut. This is accomplished by the spreading action of the thumb and fingers of the left hand acting around the heloma but a sufficient distance away to prevent interference with the operation. When the hands are in position, short sliding strokes of the knife are used to remove the topmost layers of the heloma. Again care must be exercised to keep these

strokes in a flat plane to prevent hemorrhage. When the surrounding callus area is reduced to normal (pink) layer, the nucleus which remains is dissected out in one piece. This is accomplished as in the complete dissection method.

3. *Minute Dissection (Chipping; Shaving).* With this technique the entire heloma is removed in small pieces or chips. The cutting instrument is held as before. The left hand is used to spread the skin away from the heloma. More tension must be used in this method to prevent the skin from "buckling" in front of the knife, causing a deeper cut than necessary with the resultant hemorrhage.

As in complete dissection, these latter two methods have certain advantages and disadvantages. In partial dissection and the minute dissection, chipping or shaving, the technique is much the easiest acquired by the student; it is the least painful method; there is less danger of hemorrhage, and it may be discontinued at any time during the operation. The disadvantages are that these two methods are slower, they resemble home treatment, ragged or uneven edges are more apt to remain, and the instrument edge is soon destroyed.

After the removal of the heloma, the remaining tissue is usually inflamed so that it is well to use some soothing ointment on the part, such as 10 per cent ichthyol. Pressure is avoided with felt or moleskin, according to the severity of the condition. If faulty footgear has caused the condition, it is necessary to prescribe a shoe which will meet the requirements of the individual patient.

*Radical Operative Treatment.* This method is recommended only in a small percentage of cases. It is not indicated unless non-radical procedures have failed to give the patient relief. A case which does not respond to conservative treatment is usually one of long standing which is further complicated by the formation of an adventitious bursa. Nature sometimes causes this type of bursa to form between the skin and

the bone as an additional protection against irritation.

After complete sterilization, anesthesia is obtained by infiltration with 2 per cent novocaine. The first incision is made along the medial side of the heloma. The second incision is made along the lateral side of the lesion in an elliptical manner. It is started at the same point as the first incision and finished at the terminus of the first incision. The two incisions are deepened to the bone. The isolated tissue is grasped with mouse-toothed forceps and dissected away with a scalpel. The section removed includes the heloma durum and the underlying bursal sac. If any bony enlargement is found at the first phalangeal joint, it is removed with bone-cutting forceps. The skin margins are drawn together with silk sutures. The foot is dressed with sterile gauze and sutures are removed in five to seven days.

The above procedure is contraindicated in the following cases: (1) an infected heloma which is discharging to the surface through a sinus; (2) general debilitating diseases, such as diabetes, or tuberculosis which would hinder the healing of the incision; (3) circulatory disturbances of the foot and leg.

#### HELOMA MOLLE

*Synonym.* Soft corn.

*Definition.* Heloma molle is a soft, white, macerated overgrowth of epidermis found between the toes.

*Etiology.* It is usually caused by tight fitting shoes or stockings which crowd the toes together, producing an impingement of the skin between them. The skin is thus irritated and an overgrowth of the epidermis begins. The normal function of perspiring continues, and with the crowding of the toes, evaporation is impossible. This moisture, which is acid in character, accumulates and acts upon the skin, causing it to become white, soft and macerated. Any deformity or displacement of the phalanges which causes pressure between the toes is also a causative factor.

*Pathology.* The morphologic changes occurring in heloma molle are the same as in heloma durum, except that heloma molle is not so deep seated. Inflammation terminating in suppuration is often encountered due to the action of perspiration which may produce a small fissure, permitting bacteria to enter the tissues.

*Symptoms.* Heloma molle is usually circular in form and grayish white in color. When the growth first appears it does not present a sharp line of demarcation, although later on it becomes very much outlined in comparison to the surrounding normal skin. The lesion is quite superficial and the nucleus is not very deep. The most common location is in the web between the fourth and fifth toes, and on the lateral sides of the interphalangeal joints. Soft corns usually occur in pairs and are found opposite one another. Their location represents the points of greatest pressure between the toes.

The patient complains of a burning, smarting pain which is aggravated on the wearing of tight shoes or on weight bearing.

*Treatment.* After sterilization of hands, instruments, and field of operation, the thickened mass of skin is cut away. Due to the thinness of the tissue between the toes, extreme care must be taken not to cause a hemorrhage. When all of the growth has been removed, the resulting cavity is cleaned out with alcohol or 1 per cent liquor cresolis comp. and a pad of felt or lamb's wool is placed between the toes. The patient is advised to correct the foot-gear so that the toes are not crowded. If the condition has been caused by metatarsal derangement, this latter condition should be treated with proper manipulation, massage and strapping.

#### HELOMA MILIARE

*Synonyms.* Seed corn; heloma disseminatum.

*Definition.* Heloma miliare is a small overgrowth of the epidermis composed of a nucleus with little or no surrounding callous tissue.

*Etiology.* Heloma miliare may be caused by nails protruding in the shoe, poorly mended stockings, wrinkled inner soles or shoe lining, or some foreign substance like grains of sand. A dry skin is usually a contributing cause.

*Pathology.* The hypertrophy of the epidermis occurs over a very limited area so that the growth appears to be composed of a nucleus only. The surrounding area is not involved except that it may be inflamed.

*Symptoms.* These small growths are usually grayish yellow in color and are more common in patients with dry brittle skin. Heloma miliare is usually no larger than a millet seed and is usually located on the plantar surface of the foot. As a rule the patient does not suffer the pain caused by other forms of helomata, and only when the lesions appear in great numbers do they become very annoying.

*Treatment.* After the usual aseptic precautions, these growths are removed with the point of the scalpel or the corner of a narrow chisel. In cases where the lesions are very numerous and appear in clusters, they can be treated with a 25 per cent salicylic acid plaster. The plaster is cut to the size of the cluster and placed directly over the growth. It is allowed to remain in place about five days when the lesions are more easily removed. A moleskin shield is usually sufficient to pad off pressure.

As the skin is usually dry, the patient is instructed to rub olive oil or cocoa butter into the part once a day. This will supply the oil which is lacking and will help to keep the skin soft and pliable.

#### HELOMA VASCULARE

*Synonyms.* Vascular corn; blood corn.

*Definition.* Heloma vasculare is an overgrowth of epidermis in which elongated blood vessels are found.

*Etiology.* As in heloma durum, the overgrowth of epidermis is caused by pressure or friction. The presence of blood vessels may be caused by the pinching effect of tight shoes or stockings which force these capillaries to leave the papillae

and enter the epidermis. The trimming of a heloma durum too closely is sometimes a contributing cause of heloma vasculare.

*Pathology.* There is a hypertrophy of epidermal cells, but no increase in connective tissue or in the number of blood vessels as in verruca. The blood vessels present in heloma vasculare leave the papillary layer of the dermis and enter directly into the epidermis. Inflammation is usually present.

*Symptoms.* Heloma vasculare appears the same as heloma durum except that dark red spots are seen scattered throughout the growth. These spots bleed when cut and are not to be confused with the dried blood clots sometimes found in heloma durum as a result of injury. Heloma vasculare is usually found on the plantar surface of the foot and occasionally on the toes.

Pain is more severe than in other forms of helomata and the patient usually complains of a burning sensation even when the foot is at rest.

*Treatment.* After sterilization in the usual way, a pad of felt or moleskin is placed over the condition with an aperture in the pad just about the size of the lesion. Salicylic acid ointment, 50 per cent, is placed in the aperture and allowed to remain in place for about four days. Then as much of the white macerated tissue is removed as possible. This procedure is repeated every four days until the growth disappears. The application of acids (nitric or monochloracetic) has been suggested for this condition, but the action of these agents is too severe for the average case.

#### HELOMA NEUROFIBROSUM

*Definition.* Heloma neurofibrosum is an overgrowth of the epidermis in which nerve endings and blood vessels are found.

*Etiology.* These lesions usually occur in persons with thin textured, delicate skins. Burnett and Gross have observed that this condition is often found in persons suffering with hyperthyroidism.

Traumatism produced by narrow shoes plays an important part in many cases,

especially when "overriding" causes an impingement of the lateral edges of the foot between the upper of the sole and the insole. Occasionally the condition is found in certain occupations which require the individual to thrust the foot forcibly against some hard object. This is particularly true in truck and bus drivers who are continually applying the clutch or foot brake. Another example is found in men who run large presses, which require the operator to control the machine with a foot lever.

*Pathology.* The exact pathology of this condition is not definitely known. It is believed, however, that the impingement of the lateral border of the foot, whether caused by pinching from a narrow shoe, or direct occupational traumatism, results in the papillary processes being squeezed into the already thickened epidermis. These papillary processes, of course, contain nerve endings and blood vessels.

The impingement of the papillae also retards the return circulation of the involved area and probably accounts for the congestion which is usually present.

*Symptoms.* These conditions are most commonly found on the medial plantar edge of the greater toe and the lateral plantar edge of the foot in the region of the fifth metatarsal head.

The lesion appears externally as a calloused area. Upon removal of the callosity there appears a puckering of the underlying tissues in which the blood vessels are visible. These blood vessels present a somewhat woven appearance with some running longitudinally to the surface while others are running at right angles. This twisted arrangement of the vessels is due to the fact that at the sites where this condition is most commonly encountered (namely, the medial and lateral plantar edges of the foot) there is a transition of the long papillae of the plantar surface to the shorter papillae of the dorsal surface.

While the blood vessels may be readily seen with the naked eye, we must rely on

the patient's reaction to instruments to detect the presence of nerve endings. The condition is extremely painful upon either direct or lateral pressure.

Heloma neurofibrosum can be differentiated from verruca in that it is not circumscribed, encapsulated, nor of new growth origin.

*Treatment.* Treatment of these conditions is not very satisfactory, and temporary relief is the best that can be offered under the usual palliative measures. Complete dissection of the lesion is not recommended as it always results in hemorrhage, and an irritation of the nerve filaments which lasts for several days. Careful removal of only the superficial horny layer and proper shielding, accomplish the best results from a palliative standpoint. Unlike verruca, these cases rarely respond to escharotics, such as salicylic or nitric acid.

Radical surgical removal is not advisable because of the probability of scar formation which in turn may cause the patient further irritation. X-ray or radium seems to present the most effective means of treating these cases. Even if a complete destruction is not possible, irradiation seems to inhibit further development and to accomplish permanent sedation by destruction of the local nerve tissue.

Proper shielding and the prescribing of correct shoes is necessary to all forms of treatment.

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GROSS, R., and BURNETT, E. K. Practice of Podiatry.



# BOOK REVIEWS

WILLIAM B. WHERRY, BACTERIOLOGIST.  
By Martin Fisher. Springfield, Ill., 1938.  
Charles C. Thomas. Price \$4.00.

When Charles C. Thomas makes up his mind to publish a top-notch work from a typographical angle he certainly achieves it. As a book to hold and look at, this is a gem . . . the kind of a book one wants to own and have in his library, to take down from a shelf and handle.

It tells us of the life of William B. Wherry, whose daily business was carrying on a fight against the agents of cholera, leprosy, plague, tularemia, glanders, and other forms of microscopic death. He built new pathways in bacteriology, epidemiology, and public health. Dr. Fisher tells of Wherry's ideas of raising constitutional resistance to infection by the use of vaccines; of dyes in controlling infections, and from first to last unfolds to the reader how he furthered medical knowledge and human health.

Well written, it does justice to a man whose life was interesting. To all interested in medical history and the cultural side of medicine we heartily recommend this handsome volume.

TRAITÉ D'HÉLIO ET D'ACTINOLOGIE.  
Two volumes. Edited by Ch. Brody, M.D.  
Paris, 1938. Maloine. Price 440 francs.

The publishers claim that this is the first book on heliotherapy, ultra-violet and infra-red radiation therapy in the world. It is a complete and authoritative study to which all the continental heliotherapy pioneers have contributed. It is scholarly, detailed and entirely up-to-date. Indeed, when the whole work was completed, each author provided several pages of addenda to cover the period of editing and printing.

The two volumes contain 1500 closely printed text pages. Although there is no index, there is a full table of contents and detailed summaries at the heads of chapters.

Recommended heartily to those interested in this form of therapy who are ready readers of French. Every conceivable condition in which direct sunlight or the various forms of light radiation can be used is discussed by a

master in the field. The earliest history of heliotherapy and actinology is brought to the present.

THE PATIENT IS THE UNIT OF PRACTICE.  
By Daniel W. Propst, M.D. Springfield, Ill., 1939. Charles C. Thomas. Price \$3.50.

This is just the book to give the young physician about to begin the actual practice of medicine. And many doctors of medicine, long at their calling and, at times, weary from their toil, will find much of profit between its covers.

The author tells us his purpose in writing this book "has been to systematize my own knowledge of the general principles underlying the practice of medicine and to arrange that knowledge in a form that will be concise, entertaining the usable for students. Special emphasis has been placed on the *patient* as the unit of practice. To that end, the nature of disease, the diagnostic hypothesis and the principles of treatment have been considered from the point of view of the patient as a whole in reaction to his environmental field." This, in a few words, tells the story.

The book is divided into three parts: (1) The Nature of Disease; (2) The Diagnostic or Working Hypothesis; (3) Therapeutic Principles. It is 219 pages long, clear and well written, illustrated, contains a bibliography at the end of each part, and has a glossary and an index.

TEXTBOOK OF NEURO-ANATOMY AND THE SENSE ORGANS. By O. Larsell, Ph.D.  
New York, 1939. D. Appleton-Century Company. Price \$6.00.

This book, written for the first year medical student, will, the author hopes, also serve others who have an interest in the subject.

It is a sound book, well written and with all the earmarks of having been prepared by one who knows and teaches the subject. It is 343 pages long, handsomely illustrated (232 figures, some in color), has references at the end of each chapter, and an index.

An excellent work for the purposes for which it was written.



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## EDITORIAL

### WHERE IS MEDICAL EDUCATION DRIFTING?

THAT the public has become dissatisfied with us doctors has become very obvious. Medical care costs too much and has become too chilly. Whenever there is a public unrest propagandists are quick to seize on it and to use it to their own ends. Propagandists in this connection are of two classes: first, those who raise hell just because they have a bad disposition and have no business of their own to attend to—and have an urge to interfere with those who have; second, those who shed tears with the dissatisfied in the fond hope that these crocodile tears may have a repercussion on election day. This sympathy of course is more effective if it is augmented by certain well distributed emoluments.

The wise surgeon when faced by an unfortunate outcome first asks "What have I done or not done which might have spared me the unfortunate result?" We should now examine our educational institutions and our hospitals in this honest self-searching spirit.

Confronted with the deplorable educational setup of half a century ago, when the proprietary schools were rampant, we welcomed the universities when they sought to take over medical education for us. The first thing they did, knowing nothing about the practice of medicine, was to throw out all the old. If it had a practical application it must be evil because it smelled of the past. Naturally the stuff *they* had in stock was most valuable. All the preliminary sciences had to be emphasized. The dissection of dogfish and tomcats was a necessity to the student of human anatomy. How come? He must have culture, he had to have his brains developed. Obviously no practitioner of medicine had either of these. As an instance may be mentioned that every student must gain a reading knowledge of German. That nobody ever did or could gain a real understanding reading



knowledge from the courses offered to the premedical student does not mitigate against the theory. As an example of overemphasis of a fundamental subject the dreaded P. Chem. may be mentioned. Now the poor student is threatened with physical chemistry. A physiological chemist admitted to me that what he taught the boys had no practical application, but it might have some day. I could but reply that some day all the boys would die of old age. It was a question which got there first.

After three or four years of study of subjects only remotely related to the matter of medical education the student reaches medical school. Here he may or may not meet a member of the profession he expects to enter. A physiologist some years ago presented to his class three theories about something, concluding with the remark that they could elect to accept the one that seemed most reasonable, assuming evidently that their judgment was better than his. After thinking it over, I am disposed to think he was right.

Other so-called fundamental branches likewise are taught as abstract sciences. Students learn about disease processes, but not about sick people. The knowledge gained of the basic sciences is very rarely sufficient to make it possible for the young doctor to use it in actual practice. He who has learned pathology and yet must take the specimen obtained in the operating room to the girl in the laboratory to find out what it is has spent his time in vain. The basic sciences of the first two years are but the alphabet. Unless the students continue the studies from then on, the fact that they have learned their letters will avail them but little. These studies bear about the same relation to a working knowledge of surgery that the Greek letters on fraternity houses do to a classical education.

After about six years, the student is allowed to hear the voice of the sick and perhaps touch the breasts and bellies of the afflicted. His preliminary education, if

ardently pursued in a coeducational institution, has already acquainted him with the normal. Thus, in two short years he is ready to enter an internship and proceed to instruct his erstwhile instructors.

This is what those who know nothing about it regard as a proper course for the preparation for the practice of medicine. Six years of fog, two years of light. Even yet they are not satisfied. In their ignorance they attempt to say what shall be regarded as adequate care. According to them, unless a patient has had applied to him all the possible tests science has invented, he has not been well served. They argue that even if the patient may appear to have only a wart on his nose, or a fissure-in-ano, he may have frambesia or Chinese itch.

Nor is this even yet the worst. The cost of medical care has by excessive application of pseudoscience been raised so high that it is beyond the reach of the self-reliant average man. Worse yet, the hospitals have been made as elaborate as architects with vertigo could envisage. The upkeep has become so high that the service is beyond the reach of all but the very rich or those politically endowed.

Those who have brought this on us have never breathed air outside of the editorial room or envisaged scenery beyond the confines of the campus. Of course, surveys are made from time to time. Hirelings are sent hither and yon to accumulate evidence to support conclusions already agreed on. They find a place where an underprivileged woman had seven children in a three-room house but they fail to discover where a highbrow person died of a diffuse peritonitis after having the vertebra prominens massaged and they never write up the fate of the individuals who believed faith would stay mammary carcinoma. Verily scientific investigation is great stuff if everybody understands beforehand what the answer will be. It makes it so much more simple.

The false prophets are pushing us from our high estate as a profession and are

seeking to make us their hirelings. Perhaps science can be factory made, but the art of medicine is an individual matter that can brook no rules.

A little hope looms in the distance. Hutchins of Chicago and Conant of Harvard have suggested that it might be well to take out some of the intestines of the sacred cow: to reduce the non-medical part of the course in order that the young doctor may reach the practice of his art before his sons are ready to begin their preliminary course. So perhaps there is hope—but hope is the attribute of youth, and I have lost both. Yet did not Moses smite the rock with his staff and make it into wine, or something?

If such a miracle could be possible those who have the mental agility of youth may hope that sometime, somewhere, some school may have the courage to break away from the dictators and try teaching students in such a way that they may be

prepared to render their patients, not adequate care, but such service as they want, such care as the doctor himself would want if he were in the patient's place. Boston University is actually attempting, so far as the laws will permit, to train young men to practice medicine. This means the ability and the humanity to understand the cause of their sufferings and render such service as lies within his power. Such a physician will not need to complain of ingratitude of his patients nor lack the emoluments that appertain to a well spent life.

The dictators of Europe are apparently cheap skates. They seem to have picked up the teachings of our medical dictators who are goose-stepping us into bondage and who are manhandling our boys in the name of education. We have not protested—that is, not yet.

ARTHUR E. HERTZLER, M.D.

# ORIGINAL ARTICLES

## A DISCUSSION OF THE RELATIVE VALUES ENDORSED BY THE MEDICAL PROFESSION AS THEY AFFECT MALIGNANCY OF THE UTERUS

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THE object of this paper is to bring out the relative values involved in a discussion of malignancy of the uterus from the standpoint of the value of the indwelling uterus, the cost of removal (mortality and morbidity), reliability of methods of investigation and the prevention of uterine malignancy. These are the values which face us in dealing with all organic pathology.

The mortality of the malignant uterus is evidenced with a vengeance. Our backs are now against the wall and we must definitely face the problem of the management of uterine pathology in general. We are forced to this conclusion: that with the present teaching in malignancy of the uterus, which has the popular support of the profession, the ten year salvage is little over 15 per cent. When this reprehensible mortality is compared with the trends of modern surgery, it presents a picture of great anachronism. It is my thesis that the present day teaching in malignancy of the uterus is established on a false premise.

### PROPHYLAXIS

There is no recognized prevention of fundal malignancy, in spite of the well recognized views of prevention of cervical malignancy by proper treatment of the abused cervix. The term "abused" covers the many neglected lesions of the cervix. I view the feeble advice that prevails in the

treatment of the abused cervix as the greatest paradox in preventive medicine.

Proper repair of the cervix is almost a lost art. The late Joseph Price in his last remarks before the American Association of Obstetricians, Gynecologists and Abdominal Surgeons, said he had repaired several thousand cervixes and that he had never seen a malignancy of the cervix follow proper repair. Regarding my experience of nearly forty years I can make the same statement.

Today popular adoption of the cautery in the treatment of cervical lesions is not without virtue, but it must not take the place of thorough repair. The bilateral tear of the cervix with its ever everting lips constantly predisposes to a return of the lesion for repeated applications of the cautery. The deformed organ must be returned to its normal position and outline. This is ordinary horse sense.

The late Professor Oskar Frankl of Vienna taught that as long as there was a misplaced cell found in the portio vaginalis which belonged higher up in the cervical canal, just so long was the patient predisposed to malignancy. The remedy is repair of the cervix. In my opinion and experience, 95 per cent of the deaths from malignancy of the cervix can be prevented; these are therefore human errors.

The cautery has come into favor, first, because it is easy of application, and second, because of the failures of repair

due to feeble surgery. Repairs fail because they are too superficial in the amount of tissue removed and have been made with suture material which is not sufficiently durable or substantial. We use nothing but silkworm-gut in all our repairs of the cervix or perineum.

I have no hopeless feeling regarding management of malignancy of the uterus. There is no organ where it is so often found, and therefore it should be constantly expected. There is no location where malignancy can so often be prevented and recognized at an hour when life may be saved. It is the feeble treatment and questionable management of a vital condition that I deplore.

#### REVELATIONS OF THE BIOPSY

I am not in conflict with the laboratory. I possess one manned by specialists. The value of the microscope is not in the balance for refutation, but superlative degrees of dependence must not too often be placed on ultra refinements in histopathology. The value of the biopsy must stand on the basis of the percentage of accurate results in examination of the average specimen. What are the dangers of the biopsy and what is the value of the organ examined? These are some of the values which must be discussed.

The average pathologist will not claim more than 70 per cent of accuracies from average specimens sent to the laboratory. This is sufficiently generous when one considers that treatment is determined from the laboratory report, although the pathologist has examined but one-fifteenth of the cervix and probably not over one-half or two-thirds of the mucous membrane from the fundus of the uterus.

If we were investigating an organ of vital importance to the patient and one which would not permit removal, I could accept this extensive inaccuracy as a guide to therapeutic conduct of the condition, but never when applied to the sterile uterus and its value to the patient.

Evidently it does not occur to the operator when he is curetting the uterus for diagnostic purpose, that the organ can be removed by vaginal hysterectomy with practically as low a mortality rate as that incident to the diagnostic biopsy. This is another example of values which have escaped the notice of the profession and have very materially added to the death rate from uterine malignancy.

As clinicians we are the supreme tribunal in the particular case and all look to us for final decision. It is only by summation of values which present themselves that we are able to be oriented and justified in the conduct of the lesion. Further, as clinicians it is not so much our function to say whether or not the particular cell is malignant as it is for us to deal properly with the tissues or structures in which the malignant cell is found and to determine whether or not the condition might have been prevented.

We have intensified our thoughts as to the malignancy per se and quite disregarded the function of the organ in which the malignancy is found in the life of the patient. We never give a good prognosis in malignancy of the uterus if the patient has had either diagnostic or therapeutic curettage before hysterectomy. It has been our experience that the patient who has been curetted for any purpose before hysterectomy is more apt to die from metastatic malignancy, often when there has been no local involvement at the site of removal.

Operators, in performing hysterectomy for malignancy, place clamps or forceps on the broad ligaments and the parametrial structures before any operative manipulation has been done, with the idea of preventing metastasis. Yet they have previously deliberately curetted the malignant fundus for diagnostic purposes.

The malignant cell has no appreciation for our scientific intentions. Its habits of invasion may be equally stimulated by biopsy or feeble surgery. All of us who do biopsy must admit it is a violation in

the teaching of the surgical pathology of malignancy wherever it is found. Who expects to cure malignancy when the incision transgresses the malignant area? I know of no greater violation of the principles involved than the curetting of the fundus of the uterus when there exists either chorionepithelioma or adenocarcinoma.

We are all familiar with the stimulated influence of trauma in malignancy of any organ. Who has not seen malignancy continued in the scar incident to a biopsy when further surgery has not been done, the lesion having been treated by irradiation?

In a discussion of relative values as they affect the malignant uterus, the biopsy is a violation of the execution of the common fitness of principles involved.

#### VALUE OF THE UTERUS

The value of the uterus must be measured in terms of sterility or fertility. In several thousand hysterectomies done by the late Joseph Price and myself, not over one-third of 1 per cent of the uteri removed could have become pregnant. The value of the organ was in this respect practically nil. However, its value must be discussed also from the standpoint of the price of its removal (mortality and morbidity).

During the past fifty years in the Joseph Price Hospital the mortality from vaginal hysterectomy clamp method has been a fraction of 1 per cent. There is no major operation we do which gives such a splendid postoperative history.

I wish to call attention also to the fact that in our several thousand vaginal hysterectomies clamp method, one or both ovaries were left in nearly all cases. We have had but one patient return for ovarian tumor. The removal of the uterus has been remedial in preventing the anticipated ovarian growths which would be expected in such a number of operations.

I am not in a position to say whether or not the uterus has a secretion which may act as a hormone in stimulating ovarian pathology but this exhibition is intensely

interesting. If a supravaginal hysterectomy is performed with the cervix left intact, this freedom from ovarian growth does not obtain.

#### PREGNANCY IN THE MALIGNANT OR POTENTIALLY MALIGNANT UTERUS

I know of no teaching where the value of an organ is so often pitted against the value of the patient's life as that exhibited in the salvation of the malignant uterus with the idea of future pregnancy.

In the first place, salvation of the malignant uterus with the idea of pregnancy is a violation of all teaching in the therapy of malignancy in general. One who has had any experience with pregnancy in the malignant uterus should be familiar with the fact that the pregnancy lights up smouldering malignancy and spreads the lesion like wildfire. The trauma of labor and the hypervascularization of the pregnant uterus are a combination of allies which malignancy welcomes.

#### THE CAUTERY AND VAGINAL HYSTERECTOMY AS OPPOSED TO IRRADIATION AS TREATMENT

In this discussion of malignancy of the uterus, we are confining our advice to the first and second groups of malignancy of the uterus. Here the malignancy is still confined to the uterus and we have a right to expect that we should see practically all cases before there has been greater invasion. The advocates of irradiation in the treatment of malignancy of the cervix or fundus must base their discussion on the values involved. If the malignant uterus is retained, anticipating future pregnancy, a stick of dynamite has been left within the uterus. Fortunately, nature has been wise, and she prevents pregnancy in most cases.

The indwelling malignant uterus that has been treated by irradiation is ever a source of anxiety to the patient. She often becomes a nervous wreck, since she associates the use of radium and x-ray with the treatment of malignancy in general.

If the patient is told the organ is completely removed, it immediately gives her

a peace of mind which is truly remedial. Many patients have come to me for removal of the uterus after treatment by irradiation, although no symptoms of malignancy were existing. We are justified in removing the uterus from such a patient.

We take the position that irradiation will never be the last word in the treatment of any glandular organ which permits removal, but that surgery will.

Each year has seen this opinion more and more confirmed in the treatment of early malignancy of the uterus. If one series of patients treated for malignancy of the uterus by irradiation is compared with a like series where vaginal hysterectomy clamp method has been performed, it will be found that a much greater percentage of recurrences after five years will be seen in those who have been irradiated.

It has also been our experience following vaginal hysterectomy clamp method for malignancy of the organ, if there is no evidence of returning malignancy at the end of one or two years, a greater percentage of patients will remain free from malignancy than after abdominal hysterectomy or irradiation.

It is not my intention in any way to condemn either x-ray or radium as a therapeutic remedy for malignancy. My experience in the treatment of malignancy of the uterus has, however, forcibly brought out the uncertain methods of investigation and the feeble treatment carried out with the idea of saving a worthless organ. It seems that our sense of proportions has been in error. Uterine malignancy constitutes one-third of all malignancies. It is a useless organ in over 99 per cent of these cases. The supposed

value of the uterus is ranked against uncertain methods of diagnosis and the life of the patient is endangered. Pregnancy and malignancy of the uterus are vicious companions, yet the uterus is saved. It costs in mortality a fraction of 1 per cent to remove an organ that is sterile in over 99 per cent. Better reasoning and conclusions should come out of a consideration of such relative values.

The method of operation has been discussed and illustrated elsewhere.

We endorse vaginal hysterectomy clamp method, preceded by the cautery, on account of its very low primary mortality and splendid postoperative history. The clamps minimize the operative time and shock and increase the proportion of operability over the ligature method. The operation does not shorten the vaginal canal.

The clamp method of removal of the uterus is more radical from the standpoint of tissue removed on account of the slough incident to the crush of the broad ligaments. The unsutured vaginal fornix also sloughs, removing potentially malignant tissue.

If the ten year salvage of malignancy of the uterus the world over is little over 15 per cent, what have we done for the condition in sixty years? Malignancy comes to me later today than twenty-five years ago. Let us take an invoice of the values which present themselves. By so doing we can bring our executions up to our privileges and change a ten year salvage of 15 per cent to 95. This will never be accomplished with the idea of saving a malignant or potentially malignant uterus.



# RENAL INFECTIONS IN PREGNANCY AND THE PUERPERIUM\*†

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AND

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THE occurrence of dilatation of the upper urinary tract in normal pregnancy, and the frequent association of infection and dilatation to be found post mortem in the pregnant woman have been known to clinicians and pathologists for many years. It has long been assumed that upper urinary stasis predisposes to infection, but comparatively little has been added to the older views of advanced renal disease peculiar to the parturient woman. With the development of precise methods of urologic diagnosis, the pathogenesis is clearly comprehended. While we have no intention of reviewing accepted physiologic and anatomic data or of discussing controversial points, it seems worthwhile to recall that whatever part mechanical factors play in the obstructive uropathy of pregnancy, these are abetted by atony and diminution of the normal irritability of the ureteral musculature.<sup>7,8</sup>

It is the belief of most urologists that many advanced renal lesions encountered in parous women of middle age are attributable to persistence of infection which began as acute pyelitis of pregnancy or the puerperium. An appreciable percentage of such urinary tract infections persist for months, and often for years, after the disappearance of all symptoms. Frequently they become reactivated in subsequent pregnancies. A number of these persistent silent renal infections are associated with and possibly due to unrecognized lesions of the kidney such as calculus or tuberculosis. The relationship between such persistent urinary tract infections and severe renal lesions, permanent impairment of renal

function, or predisposition to calculus formation has not been fully investigated. There is sufficient evidence, however, to emphasize the importance of adequate follow-up and persistent treatment until the urine has become sterile.

The present study is based primarily upon a series of ninety cases of pyelitis occurring in the course of 3,481 consecutive obstetric admissions to the Pennsylvania Hospital between July 1, 1934 and November 1, 1937. A second series of twenty-five cases of renal infection of sufficient severity to require cystoscopic study and treatment is also analyzed.

In the series of 3,481 pregnancies, there were ninety cases of pyelitis, an incidence of 2.58 per cent. Of this group twenty-one cases were antepartum (0.6 per cent) and sixty-nine cases (2.0 per cent) postpartum.

TABLE I  
PYELITIS IN 3,481 PREGNANCIES

Delivery	Before Only	Before and After	After Only
Low forceps.....	1	2	37
Spontaneous.....	3	4	12
Cesarean.....	0	0	9
Difficult forceps.....	3	1	9
Breech.....	0	2	2
Version.....	0		0
Delivered elsewhere.....	3		
Undelivered.....	1		
	11	10	69

Table I reveals two very interesting points. The first is the high ratio of puerperal pyelitis to pyelitis during pregnancy. This is in complete disagreement with the

\* From the Urologic and Obstetric Services, Pennsylvania Hospital (Philadelphia Lying-In).  
† Read before the Section of Genitourinary Surgery, New York Academy of Medicine, December 15, 1937.



statistics of certain authors. For instance, Morris and Langlois (1931)<sup>2</sup> found in a series of fifty-eight patients that in ten, or 17.4 per cent, pyelitis occurred in the postpartum period as contrasted with sixty-nine, or 76.6 per cent, of our series. We cannot account for this discrepancy.

It is our belief that the higher percentages of urinary tract infections following operative delivery are the result of the exhaustion of the patient and the trauma suffered by the urinary tract during the long hours of labor which predisposes to both hematogenous and lymphogenous dissemination of bacteria.

TABLE II  
TRAUMA AND POSTPARTUM PYELITIS

	Total Cases	Postpartum Pyelitis	Percentage Pyelitis
Difficult forceps.....	164	9	5.4
Cesarean.....	185	9	4.8
Low forceps.....	1579	37	2.3
Breech.....	118	2	1.7
Spontaneous.....	1402	12	0.85
Version.....	33	0	0.0

Another striking fact is the high incidence of puerperal pyelitis (58.8 per cent) in women who had suffered from antepartum renal infections. Of the twenty-one patients with antepartum infections in our series, seventeen were delivered by us and ten of these suffered acute recurrences in the puerperium.

TABLE III  
RECURRENCE OF PYELITIS AFTER DELIVERY

Antepartum (total).....	17
Antepartum (only).....	7
Postpartum recurrences.....	10
Delivered elsewhere.....	4
Postpartum recurrence.....	58.8 per cent

Our observations confirm the numerous reports in the literature, that although the acute inflammatory signs of urinary infection in the gravid woman usually subside spontaneously, the infection is rarely eradicated during pregnancy. In many instances reactivation will occur in subsequent pregnancies.

In from 7.5 per cent (Dodds) to 10 per cent (Seng) of pregnant women, culture of the bladder urine yielded bacteria, usually *B. coli*, and of these individuals 3 per cent develop acute pyelitis, whereas the general incidence is somewhat lower. This disproportion is generally attributed to ascending infection, but recovery by culture of bacteria, especially *B. coli*, from the apparently uninvolved kidney, in the presence of clear urine in clinically unilateral cases of pyelitis, suggests that the *B. coli* in the bladder urine of apparently normal pregnant women may represent silent renal infections, and that acute pyelitis often expresses the activation of existing infection, and not the introduction of fresh infection. Thus in seven of twelve cases in which *B. coli* were recovered from both kidneys, the urine from one side was clear and free from pus. Table IV shows the causative organisms and their distribution.

TABLE IV  
CULTURAL STUDIES OF THE DIVIDED URINES IN PYELITIS OF PREGNANCY

Bilateral infections:	
<i>B. coli</i> .....	12
Sterile.....	3
<i>Pyocyanus</i> .....	1
<i>B. acidilactici</i> .....	1
One side infected, one sterile:	
<i>B. coli</i> .....	1
<i>B. paracolon</i> .....	1
One side infected, one not catheterized:	
<i>B. coli</i> .....	4
One side sterile, one not catheterized:	
Sterile.....	1

In our group of patients, no etiologic significance could be attached to age, race or parity. The month of pregnancy in which the infection manifested itself is shown in Table V. The definite peak of infection

TABLE V  
ANTEPARTUM PYELITIS

Month	Cases
3	1
4	1
5	4
6	8
7	3
8	1
9	3

found in the fifth and sixth months is explained by the stasis resulting from ureteral atony and dilatation, which are

most marked at the sixth month of pregnancy (Traut and McLane<sup>7,8</sup>).

**Severity.** Pyelitis of the puerperium is usually milder than antepartum pyelitis. We believe that this is explained by the absence of ureteral obstruction, and by the gradually increasing tonus of the ureteral musculature. Persistence of severe urinary tract infection suggests a complicating lesion. This is especially true after the patient has been delivered, and the factors contributing to urinary stasis thus eliminated.

TABLE VI  
METHODS OF TREATMENT

	Medical	Cysto- scopic	Surgical
Antepartum.....	16	5	0
Postpartum.....	65	4	1

In the series of ninety cases of pyelitis, nine were severe enough to require cystoscopic drainage. Four of the women cystoscoped were in the puerperium, and one of these had an ectopic kidney, another a calculous pyonephrosis.

**Cystoscopic Data.** In another group of twenty-five patients, cystoscopy was required. The indications for instrumental examination were: severity of infection, fever persisting longer than five days, evidence of a complicating lesion, or marked renal dysfunction. The series comprises fifteen prenatal and ten postnatal cases, among which were three complicated by ureteral calculus, and one by ectopic kidney. The latter and one patient with calculi had pyelitis only in the puerperium. As might be expected, renal dysfunction in bilateral cases was most marked on the side yielding the most pus and local signs of inflammation. On the whole, dysfunction was very moderate in the absence of antecedent surgical lesions or very severe pyelonephritis. The blood urea nitrogen usually suffered only a transient elevation.

Miscarriage occurs more often in severe cases of pyelonephritis treated conserva-

tively than in those treated by catheter drainage.

Three of the fetuses which succumbed were in cases that had been subjected to cystoscopic study and treatment, but it may be recalled that only serious cases were subjected to such treatment. In one instance a woman at the eighth month delivered herself of a dead infant while there was an in-dwelling catheter in her left kidney which was infected with *paracolon bacillus*. In the second case a woman three months pregnant with bilateral *B. coli* renal infection aborted after eighteen days of high septic fever which an in-dwelling (right) catheter failed to control. The third patient, a woman five months pregnant had bilateral renal infection with *B. coli*, and blood stream infection with *B. coli*. She failed to improve with prolonged catheter drainage. Labor was induced thirty days after admission—the child was stillborn. The patient's temperature was normal six days later.

**Treatment.** The treatment of pyelitis complicating pregnancy and the puerperium is usually divided into "medical" and "surgical." By the former term we mean non-instrumental therapy. Briefly, this consists of rest in bed, sedation, catharsis and forced fluids. We feel that adequate intake of fluid is of more value than antiseptics administered by mouth. There is no single urinary antiseptic ordered routinely, and we can attribute no especial advantage to any of them. The reaction of the urine is tested every day, and recorded in terms of the hydrogen ion concentration. In most cases alkalinization of the urine is undertaken with sodium bicarbonate or similar preparations. Should the infection fail to respond, the urine is acidified with ammonium chloride or sodium acid phosphate. The ketogenic diet has been considered too hazardous to justify its use in the pregnant or lactating woman. Mandelic acid mixtures are occasionally employed in some of the chronic infections. Sulfanilamide is useful, but should be used very

cautiously in view of the ill-defined status of its toxicity.

In every case the bladder urine is cultured, a phenolsulphonphthalein test performed, and the blood urea nitrogen level determined.

Should such conservative therapy fail, as evidenced by persistence of fever or increasing weakness of the patient, we resort to cystoscopic drainage. Although each case is individualized, we consider that five days of fever without signs of amelioration indicate a more aggressive diagnostic and therapeutic attack. Both ureters are catheterized, and in-dwelling catheters are usually left in place on one or both sides. We feel that the use of in-dwelling catheters is logical in view of the fact that dilatation of the upper urinary tract is present in nearly every pregnant woman. The advantages to be obtained from the relief of stasis, more than compensates for any slight ureteral trauma.

Differential bacteriologic and functional studies are carried out at the time of cystoscopy. In-dwelling catheters are usually left in place until the temperature has been normal for forty-eight hours.

*Follow-Up.* A very important part of the management of pyelo-ureteritis consists in following and treating the patient until her urine becomes sterile. All patients who have had pyelitis are routinely referred to the cystoscopic out-patient clinic where treatment is continued until repeated cultures of the urine are sterile.

Should infection persist more than three months a complete urologic study is made, including differential phenolsulphonphthalein tests and roentgenograms of the renal and ureteral areas. The bladder is examined cystoscopically, both ureters are catheterized, and the urine from each kidney is cultured.

It is this group of patients with silent renal infections that has been so neglected in the past. Many urologists feel that much of the renal disease found in middle-aged women is due to such infections, which may have persisted for years.

## CONCLUSIONS

1. Antepartum pyelonephritis is usually much more severe than the puerperal type.
2. Severe pyelonephritis in the parturient woman should be treated by the in-dwelling ureteral catheter.
3. Failure to control severe acute pyelonephritis by catheter drainage is usually an indication for termination of pregnancy.
4. Renal infections occurring during pregnancy are usually (58.8 per cent) reactivated by the trauma of labor and delivery.
5. The exhaustion of the patient and the trauma suffered by the urinary tract during the long hours of labor are probably responsible for the higher percentages of urinary tract infections following operative delivery.
6. Severe and persistent pyelitis following delivery is strongly suggestive of calculus or renal abnormality.
7. All patients with urinary tract disease should be followed until the urine is sterile.
8. Persistence of urinary tract infection demands thorough study and aggressive treatment.

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# RECURRENT RENAL AND URETERAL CALCULI: MANAGEMENT AND PREVENTION\*

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## I. INTRODUCTION

THE most noteworthy advance in the prevention of recurrent urolithiasis lies in the recognition of the fact that the presence of the original stone is but a sign of an underlying pathologic state, either local or general, and not a disease entity per se. The removal of the stone by spontaneous, instrumental or operative means is only a step in the management of the disorder. To be sure, our knowledge of the etiology of stone formation is still incomplete and fragmentary, but experimental and clinical investigations of the last few years have corroborated the old ideas (stasis and infection), and discovered new factors (diet, vitamin A deficiency, chemical condition of the urine, lesions of the renal papillae), which thus form the basis for a rational therapeutic attack. Perhaps an analogy may be drawn with peptic ulcer in which we still do not know the ultimate cause, but are familiar with the mechanism and predisposing causes, and are enabled to control the malady.

This paper will first discuss in condensed fashion the generally accepted pathologic states leading to stone formation; next present in some detail the régime now followed by us to prevent recurrences; and finally, analyze a series of 164 consecutive cases of upper urinary tract calculi seen at the Dallas Medical and Surgical Clinic up to November, 1937.

This study deals largely with personal observations and is in no sense a comprehensive review of the literature. It has seemed to us that certain simple therapeutic measures directed against the tangible factors we know to underlie stone

formation might well be reëmphasized. Furthermore, the recent remarks of Morrissey<sup>1</sup> seem particularly timely to us and we are in accord with his admonition not to follow theoretic considerations beyond their possible ultimate practical worth.

## II. WHAT CAUSES STONES?

At the outset two facts must be emphasized. First, all stones may be divided roughly into two general classes, i.e., primary and secondary calculi; and secondly, no one cause accounts for all or even a majority of stones, but two or more of the known possible causes may be combined in any given instance.

A primary stone is one occurring in the absence of any other demonstrable pathologic state of the kidney. A secondary stone is one occurring coincidental with stasis or infection. A urinary stone is composed of crystalline salts deposited about a nucleus and held together by a matrix of organic material. Randall<sup>2</sup> by brilliant deductive and inductive experiments has recently shown that in the case of primary stones the nucleus is a subepithelial plaque of calcium at the site of the renal papilla. As this plaque becomes denuded of epithelium and bathed in the calyceal urine, it serves as the nidus for deposit of the supersaturated salts and a stone forms. As to the cause of formation of the subepithelial calcium deposit, Randall is still in doubt; perhaps the concentration and excretion of bacterial toxins by the kidney is involved. The process is essentially similar in secondary stones except that the nucleus may be a primary stone, detritus,

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clot etc., and the growth of the stone is enhanced by the additional renal pathology present.

The mechanism whereby the constituents of the urine are held in supersaturated solution is discussed in a recent paper by Sisk and Toenhart.<sup>3</sup> They feel that this supersaturation depends on the acidity of the urine and the action of neutral salts rather than on the "protective" action of colloids. Certain Dutch investigators<sup>4</sup> on the other hand state that the precipitation of the colloids is the primary process in stone formation, and that such flocculation is followed by incrustation with crystalline salts. In any case it is obvious that under certain circumstances urinary salts tend to precipitate out of supersaturated solution, deposit themselves on a suitable nucleus, be held together by viscid organic material, and grow by repetition and continuation of the process.

In all discussions of the etiology of calculi racial and geographic influences are stressed. The most illuminating recent paper on this aspect is that of Vermooten in South Africa, who found<sup>5</sup> an almost negligible incidence of stone in the natives (one case in 90,000 admissions) on their normal acid ash-low calcium-high vitamin A diet, in contradistinction to an incidence of stone of one case to 460 admissions in the white population. He believes that the only pertinent fundamental difference in the Negro and Caucasian groups studied is the diet. We pass now to the known predisposing causes.

1. *Stasis*. Stasis of urine in a poorly draining kidney (ureteropelvic obstruction, aberrant vessel, ureteral stricture, neuromuscular atony, reduplicated renal pelvis, nephroptosis), favors stone formation. A striking example of this has recently been quoted by Vermooten. Sisk has noted the importance of the element of time in maintaining the state of supersaturation of urine until it is voided. While urostasis per se does not cause stones, its untoward effect on this time interval, as well as its rôle in

prolonging urinary infection, is a matter of everyday experience.

2. *Infection*. A good proportion of stones (31 per cent in our series) form in the absence of infection in the urinary tract, and conversely long-standing urinary sepsis often exists independent of stone formation. However, both experimental evidence and clinical observation point to the causal association of renal sepsis with stone formation (Keyser<sup>6</sup>). Remote foci of infection likewise have been shown by Rosenow and Meisser<sup>7</sup> to send specific stone-forming strains of bacteria to the kidney. Possible modes of action of infection are by urea-splitting organisms alkalizing the urine, by the upsetting of the colloid-crystalloid balance, by the bacteria themselves forming a nucleus for crystalline precipitation.

3. *Calcium Metabolism*. Calcium metabolism as it pertains to stone formation has been discussed by the Massachusetts General Hospital investigators.<sup>8</sup> Despite careful search for hyperparathyroidism since this stimulation of interest in the subject in 1933, only one proved case has been found in Dallas. Although frank hyperparathyroidism is not nearly so common as the original reports indicate, it seems likely that other disorders marked by excess urinary calcium excretion occur and that the excess concentration of calcium salts in the urine then predisposes to stone

CALCIUM BALANCE STUDY  
8/19/36 Began Low Calcium Diet (Less than 100 Mg. Intake)

Date	Serum Calcium, Mg.	24 Hour Urine, C.c.	24 Hour Urine Calcium, Mg.
8/20/36	12.25	4,100	249
8/21/36	11.50	3,300	244
8/22/36	10.65	3,600	191

formation. Marquadt,<sup>9</sup> on the basis of blood calcium and phosphorus studies in thirty-seven cases, feels that the blood calcium levels in urinary lithiasis and in

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the absence of hyperparathyroidism are commonly found varying beyond the supposedly normal limits. We have four cases which bear out his observations, and one such is cited in the table on p. 349. This was a 40 year old male who had passed several stones. He drank much milk. There was no evidence of skeletal pathology or of parathyroid tumor. Exploratory operation did not seem warranted, particularly as the calcium metabolism responded to dietary measures.

4. *The chemical condition of the urine* relates chiefly to the degree of acidity or alkalinity of the urine and the state of supersaturation of the urinary crystalloids. In acid urine, uric acid crystals, urates, and oxalates precipitate. In alkaline urine, phosphates and carbonates of calcium, magnesium and ammonium precipitate. The higher the concentration of a given salt the more likely it is to crystallize out and vice versa.

5. *Vitamin A deficient diets* were observed to produce a high percentage of urinary calculi in experimental rats as early as 1917.<sup>10</sup> This observation has been confirmed by several investigators, but particularly by Higgins<sup>11</sup> who has contributed much ingenious investigative data and has secured worthwhile clinical results based on this evidence. This, combined with our knowledge of the keratinizing effect of vitamin A deficiency on epithelial structures in general (Wolbach<sup>12</sup>), lends credence to the view that such a deficiency results in an unhealthy condition of the renal pelvis mucosa with desquamation of the cornified epithelium, ulceration, and inflammatory reaction. The possible beneficial effect of vitamin A on infections in general should also be mentioned. The astonishingly high incidence of vitamin A deficiency in Americans has been pointed out by Jegher<sup>13</sup> who found in a group of medical students that 35 per cent had low photometer readings and 12 per cent had clinical manifestations of the deficiency. He also concluded that 4,000 international units of vitamin A daily represent the

minimal requirement for a healthy adult. Jeans<sup>14</sup> likewise found photometric evidence of vitamin A deficiency in 35 per cent and 24 per cent respectively in two groups of school children. By the administration of 6,000 international units daily he brought about improvement in the dark adaptation and photometric tests. More recently, Ezickson and Feldman<sup>15</sup> studied a group of cases of renal lithiasis and found 98 per cent associated with vitamin A deficiency. They were unable to influence the photometric evidence of this deficiency by prolonged vitamin A administration. It is of some interest that in their controlled group of fifty patients free of urinary calculi, they found only four cases showing evidence of vitamin A deficiency (cf. Jegher 35 per cent above).

### III. THE PREVENTION OF RECURRENT CALCULI

The complete removal of existing stones is the first step in preventing a recurrence. Cabot and Crabtree<sup>16</sup> in 1915, from the Massachusetts General Hospital, found an incidence of recurrence in renal stone cases of 51 per cent following operation. Later, Barney<sup>17</sup> by routine postoperative roentgenograms demonstrated that in many instances fragments of stone remained to serve as the nucleus of a new calculus formation. This type of recurrence he designated as "false" recurrence or "left-overs" but as the end result, as far as the patient is concerned, is identical with a "true" recurrence, it is proper to consider this group here also.

1. *Operative Measures.* In our personal operative approach on nephrolithiasis we attempt to combine several technical features advanced by others and have nothing original to offer. The most helpful of these measures is roentgenography at the operating table. In large single stones in the pelvis this is unnecessary, but in multiple calculi, staghorn calculi, and small stones in the calices, a small plate taken of the exposed kidney proves that no remnants are left or facilitates further search

and removal. Any type of portable x-ray unit can be used for this plate, and with the newer portable machines immediate fluoroscopy can be done with much greater simplicity than formerly. All in all this Roentgen control is easy of application and affords a helpful sense of security.

Thorough saline lavage and suction with catheter and syringe of the pelvis and calices at times has yielded unsuspected spicules, and is always efficacious in washing out "sand," débris, and blood clot. The maneuver of Von Lichtenberg, as described by Counsellor,<sup>18</sup> in which a v-shaped incision in the pelvis is made, after the renal parenchyma has been stripped bloodlessly by blunt dissection from the posterior aspect of the pelvis out to the bifurcation of the calices, has been of value in instances of staghorn calculi and cases of intrarenal pelvis. Since the advent of the Lowsley ribbon gut suture, nephrotomy of moderate extent may be done almost with impunity so that stones not easily accessible through the pelvis may be removed without mutilation of kidney tissue and accurate hemostatic approximation and healing ensue.

The value of nephrostomy drainage after removal of stones has been strongly emphasized by Counsellor and Hoerner<sup>19</sup> in cases of extensively damaged kidneys and marked infections. We can likewise attest to the smoother convalescence, rapid clearing of infection, and return of function in kidneys so treated. It is our practice, when a stone of any size is removed through the cortex, to bring a No. 26 open-end nephrostomy tube out through the same opening, or through the lower calix. Frequent irrigations during the convalescence are employed to wash out clots and débris. Except in unusual circumstances the tube is removed in two weeks and the sinus is found to be well healed in a few days more. Partial resection has been employed by us in two instances. Once to remove the poorly draining stone-filled lower portion of a reduplicated pelvis, and again to excise a hopelessly abscessed upper pole and occluded calyx containing a large stone, the

opposite kidney being destroyed. Ribbon gut was used to advantage to bind a thin layer of muscle tissue over the cleanly sectioned renal parenchyma.

The freeing of the ureteropelvic junction from obstruction is of paramount importance at the time of operation. Such obstruction is most often due to fibrous bands, aberrant vessels, angulation from nephroptosis or inflammatory stricture. It is our procedure always to deliver the kidney as completely as possible, to remove the stone, then thoroughly strip all extraneous structures away from the pelvic outlet. Bougies are passed through the opening in the pelvis to dilate the outlet further. The kidney is then placed and held in a high position with proper angulation of the ureter by a Deming nephropexy in which the leaves of the perirenal fascia are sutured below the lower pole of the kidney to form a supporting hammock. In regard to ureteral stones requiring operation, we prefer the midline incision for all stones below the brim of the pelvis. So much for the actual surgical corrective measures. Two cases illustrating combinations of these points will be cited.

CASE 1. A 40 year old woman was found to have a staghorn calculus completely filling the left kidney pelvis and calices. (Fig. 1.) Operation disclosed a kidney of normal size and consistency, lying fairly low and quite mobile. It was thoroughly freed up by blunt and sharp dissection, and the ureter isolated. A large stone could be felt in the pelvis of the kidney which was chiefly intrarenal. The parenchyma was peeled off the posterior aspect of the pelvis, which was then opened and the major portion of the stone removed. A fragment in the lower calyx was removed separately, and then a fragment in the upper calix removed through a nephrotomy opening. Fluoroscopy showed all pieces of the stone thoroughly removed, and this was confirmed by a plate taken immediately. A rubber tube was placed through the nephrotomy opening and brought out through the posterior portion of the wound. Ribbon catgut was used to bind up and reconstruct the kidney and the pelvis was closed with a small continuous suture. A Deming nephro-



pexy was done. The patient had a remarkably smooth convalescence. The tube was removed at the end of two weeks, and she was

Examination of the left kidney at this time showed it to be free of pus and of good function.



FIG. 1. Case 1. Before injection, showing large staghorn calculus.



FIG. 2. Case 11. Showing bilateral calculi.

discharged a week later with the wound completely healed. The infection, which was improved immediately, was finally cleared up by mandelic acid and pelvic lavage.

CASE 11. A 38 year old woman had bilateral renal calculi, the right kidney being almost entirely destroyed. (Figs. 2 and 3.) The left kidney was operated on first; it was twice normal size and was covered with inflammatory adhesions. The tissue at the lower pole was solid and of good consistency. The ureteropelvic junction was visualized and appeared normal. The upper pole of the kidney was softened, and the stone in the upper pole could be felt by passing needles through the cortex. An incision was then made directly over it and about an ounce of purulent urine escaped, while the stone, lying free in an occluded cavity, was removed. The upper quarter of the kidney was then resected by a wedge-shaped incision, doing away with the diseased upper pole. The edges of the wound were approximated with Lowsley ribbon gut tied over pieces of muscle. The patient did very well, and six weeks later underwent a right nephrectomy.

2. *Urinary Antiseptics.* The revolutionary development of urinary antiseptics within the past two years is familiar to everyone, and the methods of administration are well standardized. Customarily we start the patient on a ten-day course of mandelic acid as soon as possible after the removal of the stone. During its administration water, in amounts desired by the patient, is the only liquid allowed. Between courses of mandelic acid, methenamine and sodium acid phosphate or enteric coated tablets of ammonium chloride in doses of 60 gr. a day are given. As a rule the response is rapid, but if it is unsatisfactory we have had no hesitation in using sulfanilamide in 40 gr. doses daily. This is usually accompanied by gratifying results. In a few cases of persistent coccal infections injections of neoarsphenamine have been given but with no striking superiority to the above plan. In our opinion the merit of caprikol, pyridium, serenium, picochrome, methylene blue,

alkalinization, the balsamics, and small doses of methenamine lies in the occasional relief of bladder irritability they afford rather than from any significant antiseptic action. We have practically discarded them.

If the urine does not clear up satisfactorily with medication by mouth, cystoscopy and pelvic lavage are done, using acriflavine. Unless there is obstruction to a No. 6 catheter no further dilatation is attempted. In several instances of persistent pyuria the kidney specimen was negative for pus and organisms, while the lower urinary tract was the origin of the findings (prostate).

It will be noted that no special reference has been made to the type of infecting organism; in fact, while making frequent routine cultures and stained smears, we have applied the treatment outlined above irrespective of the bacteria. The results of cultures in 100 patients with infected bladder urines were: *B. coli* 56 per cent; *B. coli* plus staphylococcus 26 per cent; staphylococcus 16 per cent; streptococcus 2 per cent. In the future we intend to differentiate *B. proteus* from the colon group, and attack it immediately with large doses of sulfanilamide. The low incidence of the streptococcal infections in our series is noteworthy as compared to that of Cabot.<sup>20</sup>

3. *Diet.* The desiderata of the diet are simplicity and theoretical restriction only to a point commensurate with the probable actual benefit. A reasonable objective is to modify the type of food intake and adjust the acidity and dilution of the urine to where no crystals precipitate from the urine at any time. A regrettably small proportion of stones recovered by us have been analyzed. An improvement in this regard is one of our main future objectives. We have assumed, however, that calcium is the chief basic element in any radiopaque stone (97.6 per cent opaque and 2.4 per cent non-opaque in our series). In accord with this assumption, and with the belief that hyperexcretion of calcium is favorable to stone formation, we restrict the calcium

intake in the diet (dairy products and eggs) in all cases. To cut down the oxalates, tomatoes, spinach and beans are inter-



FIG. 3. Case 11. Retrograde pyelogram before operation.

dicted. Unless the pH of the urine is very low, no difficulty has been experienced with uric acid crystals appearing in the urinary sediment, hence no restriction on meats has been urged. Specific instructions to the patient are: "Avoid altogether these foods in any form, raw, cooked, or mixed with other food: milk of any kind; cheese; eggs; nuts of any kind; beans; tomatoes; brown bread or any bran food. Eat: meat of any kind; any vegetable not listed; white bread; butter and oils; sugar. Regulate fruit and fruit juices according to pH as directed."

4. *Acidification of the Urine.* In our observations with the above dietary precautions, high fluid intake, and in the absence of severe infection, the urine is almost invariably free of crystals of any kind at a pH of 4.5 to 5.5 as determined by nitrazene paper. This pH may be obtained on the diet alone, but as a rule we find it necessary to give the enteric coated tablets

of ammonium ehloride, gr. 30 to 80, daily for several weeks, gradually reducing the dosage and finally omitting the drug as conditions warrant. The hazard of prolonged use of urinary acidifiers has been noted by Oppenheimer.<sup>21</sup>

Our failure to analyze the stones as a matter of routine prevents us from speaking authoritatively on the value of maintaining an alkaline reaction in cases of uric acid and urate stones. As previously stated, we have merely adjusted the pH to a point at which no crystalline elements were seen in the freshly voided specimen. Hereafter in a stone of the types mentioned, we plan to keep the urine alkaline as recommended by Twinem<sup>22</sup> and others. We are reasonably certain that we have never encountered a cystine stone either in this series or elsewhere.

5. *Fluids.* The virtue of water in urologic ailments is legendary. As stated by Young, the use of pure water in large amounts is probably the most valuable prophylactic treatment which can be actively put into practice and continued indefinitely without repugnance. The dilution of the urinary solids and the mechanical flushing of the urinary passages are well accomplished by this means. Our injunction, which is to drink a "glass an hour" besides the fluids at mealtimes, results in a 24 hour intake of 2,500 to 3,500 c.c. and keeps the range of specific gravity at about 1.005 to 1.015. (Of course, while mandelic acid is being administered the intake is lower.) It has seemed reasonable to advise distilled water only where there is a high limestone content in the regular supply, and in certain intractable "stone formers" where it is proper to grasp at even a straw. Fruit juices are allowed insofar as they do not greatly alter the desired pH. In regard to coffee, tea and alcohol, we have only our impressions to guide us. Our rule of thumb is to forbid their use while infection is present and to allow them in moderation otherwise.

6. *Foci of Infection.* As soon as possible after the removal or passage of a stone, and

coincidental with the other prophylactic measures, foci of infection are actively attacked. Although no comparative tabulation has been made by us we rank in order of importance—abscessed teeth, infected tonsils, chronic prostatitis, female bladder neck infection, chronic endocervicitis, colonic stasis, sinusitis, gall-bladder disease, and chronic appendicitis. Whether the correction of these abnormalities acts specifically or through the improved general bodily health, we are not prepared to say, but we are convinced of the salutary effect of such correction on both urinary tract infections and stone formation. The therapy may be prolonged and the results gradual (prostate), or at times rapid and spectacular (teeth, tonsils).

7. *Vitamin A.* In spite of the conclusions of Ezickson and Feldman, referred to above, in which they were unable to influence experimentally vitamin A deficiency in humans by vitamin therapy, we shall continue to give vitamin A routinely to stone-forming patients. Indeed in their cases of urolithiasis no existing stone increased in size, and no new one formed while the patient was on proper vitamin A and dietary therapy. We use a commercial fish-oil concentrate containing 8,500 international units to the capsule. At first two capsules a day, and later one capsule are given.

*X-Ray Follow-Up.* The importance of a check-up K.U.B. plate every six to twelve months is emphasized to every patient. The intravenous pyelogram is also used freely to demonstrate the anatomic and physiologic status of the kidney. By such a follow-up stones may be detected in their incipency and conservative measures be applied with benefit.

#### IV. THE DISSOLUTION OF CALCULI

In 1935, Higgins<sup>23</sup> reported twenty-three cases in which on the acid ash high vitamin A diet all calculi were dissolved. Recently, however, Pollack and Oppenheimer<sup>24</sup> from Beer's clinic, studied under the most favorable circumstances twenty-

seven cases of stone on the Higgins régime, and in no case obtained any evidence of solution of the calculi. This latter outcome has been the experience of urologists in general. Personally we have seen no evidence of solution of calculi on the most carefully followed Higgins régime. In a few cases we have tried renal lavage with 1 to 2 per cent phosphoric acid as advocated by Randall, but have been more impressed by the occurrence of cystoscopic reactions than of any significant effect on the stone. In brief, it seems likely that an occasional small stone or a rare soft formed large stone may be dissolved, but this possibility should not lead one to temporize seriously with stones producing symptoms or causing renal damage.

#### V. ANALYSIS OF 164 CASES OF RENAL AND URETERAL CALCULI FROM THE DALLAS MEDICAL AND SURGICAL CLINIC

*Incidence.* The 164 cases of proved renal and ureteral stone were found in the examination of approximately 40,000 patients admitted to the clinic. This is an incidence of one such calculus case in every 244 admissions.

TABLE I  
INCIDENCE OF RECURRENCE

	Renal	Ureteral	Total
Number of cases.....	86	78	164
Recurrence.....	33	14	47
Per cent recurring....	38.4 per cent	18 per cent	28.6 per cent

In our figures on recurrence, a patient is so considered if he gives a history of spontaneous passage of, or operation for one or more stones prior to examination by us. This obviously does not take into account the fact that the present and previous stones may have formed simultaneously, and hence may not constitute a true recurrence; however, since it is impossible to differentiate in such cases, we have arbitrarily listed them under the

heading of recurrences. Furthermore, in only a very few cases was an x-ray plate made immediately postoperatively; hence, a small stone or spicule missed at operation would later erroneously be classed as a recurrence. These factors may account for our finding of 28.6 per cent recurrence, while Keyser, after reviewing many of the series of cases in the literature, concludes that the chances of recurrence are 4 to 20 per cent.

TABLE II  
TYPE OF STONE

	Renal	Ureteral	Total	Percentage
Single.....	45	64	109	66.4
Multiple.....	41	14	55	33.6
Bilateral.....	10	0	10	6.1
Staghorn.....	12	0	12	7.3

Of the twelve staghorn cases encountered in our series, none were bilateral staghorn, although in four instances there were other smaller stones present.

*Pyuria.* Of the 164 cases, 113 or 69 per cent showed pus in the urine graded one plus or more, while 31 per cent had essentially negative urinary sediment.

TABLE III  
TREATMENT OF 164 CASES OF RENAL AND URETERAL STONES

	Passed Spontaneously 17 or 10 per cent		Passed with instrument 54 or 33 per cent		Operation 56 or 34 per cent		Untreated 37 or 23 per cent
	Renal	Ureteral	Renal	Ureteral	Renal	Ureteral	
Number.....	4	13	6	48	41	15	Deferred, refused, or returned to local physician.
Percentage of total renal or ureteral stones respectively.....	5	16	7	61	48	19	

In the fifty-six cases operated upon sixty-four major procedures were done as follows: pyelotomy twenty-one; ureterolithotomy twenty; nephrectomy sixteen;

nephrolithotomy five; resection of portion of kidney two. There were no operative deaths in this group.

As noted above, thirty-seven cases or 23 per cent of the total were untreated at the clinic, i.e., they either refused the advice given or deferred action, or else were returned to their local physicians.

**Outcome.** Beginning in January 1936 a concerted plan of preventive measures, as described above, was introduced. Accordingly the cases have been divided into two groups treated before and after this date.

Of 136 cases handled prior to January 1, 1936, fifty-five patients were returned to the care of their local physicians; five patients failed to return as instructed and are not available for follow-up. Of the eighty-one cases followed, sixty-five consider themselves well, although nineteen still had pyuria when last examined. Eight had recurrences while under treatment or observation. Five have died, one due directly to recurrence of stone with uremia.

Of the twenty-eight cases cared for since January 1, 1936, twenty-five are available for follow-up data, three having been lost from observation. Of these twenty-five patients, twenty consider themselves well and are free of stones although seven show some degree of persistent pyuria; two, on account of their general condition, are being treated conservatively, their stones not having been removed; one refused operation, went elsewhere and died; one has a recurrence thirteen months after operation elsewhere; and one has a small renal stone which an attempt is being made to dissolve, a ureteral stone having been successfully removed previously.

In this recent group of cases significant foci of infection were found as follows: teeth, eight cases; tonsils, six cases; prostate, ten cases; female urethra, four cases; gall-bladder, one case. No focus of infection was found in six cases (20 per cent). In other words, 80 per cent had foci of infection.

In the fifteen cases in which the urine is now free of pus and negative on culture, an

average period of six weeks treatment was required.

## VI. SUMMARY AND CONCLUSIONS

1. Five important pathologic states associated with stone formation have been reviewed. They are: (1) stasis, (2) infection, (3) disturbance of calcium metabolism, (4) the chemical condition of the urine, and (5) vitamin A deficiency.

2. An outline has been presented of the plan now followed by us for the past twenty-two months to prevent recurrence. It embraces and takes cognizance of (1) operative measures, (2) urinary antiseptics, (3) diet, (4) acidity of the urine, (5) fluids, (6) foci of infection, (7) vitamin A administration.

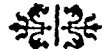
3. Progress in the dissolving of calculi may be expected in the future. In our cases we have found it of no practical worth.

4. A group of 164 personal cases has been analyzed. The low recurrence rate in the cases treated by the plan described is encouraging.

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# THE SURGICAL PROBLEM OF THE DEGENERATIVE GOITER HEART

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THE normal end result of all goiters is death from heart failure. Generally speaking this is as true of Graves' disease as of the colloid goiters. The problem therefore, in the first place, is to determine when a goiter begins to injure the heart, and in the second place to decide what to do about it. Even more, knowing that all goiters will eventually injure the heart, there is no reason why one should wait until such injury has begun.

## CLASSIFICATION

Goiters beyond the age of adolescence may be divided into the hyperplastic toxic as we see it in Graves' disease, and into the degenerative toxic goiters, the toxic adenomas, the old colloids, or whatever name is applied to them. Replacing this pathologic designation, a convenient clinical classification, as proposed by Davison, is acute and chronic goiter.

The first group, the acute, is synonymous with the hyperplastic. It is represented by the Graves' type of disease which is attended by marked loss of weight, pronounced nervousness and in some cases by eye signs. Since these may develop in a few months or even less, they are obviously acute in onset, even though chronic in ultimate course.

In contradistinction to these is the chronic type of thyroid disease which requires many years for the development of obvious toxicity. The lesion in these cases may properly be designated as chronic toxic, since it is just that, both in onset and in course. Goiters of this type are so insidious in onset that it is often impossible to say when they begin to exert a deleterious influence on the patient.

It would add much to clinical clarity if practitioners would adhere to this simple

classification rather than to attempt to employ the terms usually used by pathologists, classifications which they do not understand themselves and will not understand until the surgeon takes them into the hospital in order that they compare the clinical with the pathologic.

The goiters of adolescence will be here ignored because they are, or at least may be, but physiologic disturbances in the beginning and may end in recovery.

*The Normal Gland.* The first step in the study of the pathology of an organ is to consider the normal. Unfortunately we do not know the structure of the normal thyroid gland.

This much we may say: beginning with a cell mass in the fetus, follicles are gradually formed somewhere near the middle to the end of gestation. In childhood many well formed follicles containing colloid are interspersed with cell masses which have not yet formed acini. In adolescence and early adult life the acini dominate the picture, there being but few interacinal cell masses remaining. The acini are lined with uniform cuboidal or columnar cells and the colloid which they contain is uniformly acidophilic when stained. But the colloid is thin, palely staining, resembling more the colloid in Graves' disease than the colloid of the adult gland. Perhaps this is the reason the child is as restless as a patient with Graves' disease.

In middle life the cells are flat, and the colloid is uniformly acidophilic. In nearly all of the glands in mid or later life the colloid tends to lose its specific stainability. The time when this occurs varies greatly in different persons, but when it comes the structure is then comparable with the structure of degenerative toxic goiter. The only difference is that there is no goiter—



no enlargement of the thyroid. At least there is no enlargement palpable in the clinic. A fat patient may hide a goiter of a size which would be perfectly obvious in a thin person. Likewise the goiter may be hidden behind the sternum and so escape the prying fingers of the clinician. Therefore it is not so much what the patient has as what is evident in the clinic that permits the diagnosis of a goiter. This fact is of fundamental importance.

There may be much more extensive degeneration in a thyroid that is not palpable than in one that is. Therefore the size of the gland is not a guide to what it may be doing to the patient. It is very necessary that we divest our minds of the belief that the size of the thyroid has anything to do with determining whether or not it is normal. The acinal epithelium in a gland, and the state of the colloid, that is even less in size than the normal may indicate that the gland is toxic. Size is not a measure of the degree of toxicity.

It must be added that there is a great variation in the thyroids of persons of the same age. One cannot guess the age of an adult from the structure of the thyroid gland. It is like judging the age of a horse by its teeth. We can say only that the horse is more than eight years old. In the same way we can say the person who harbors a certain type of thyroid has passed the age of puberty. In advanced changes of the nongoitrous thyroids associated with the degenerated epithelium, naturally, the colloid also changes until it has lost all resemblance to its normal self. In such cases there cannot be a shadow of a doubt but that the gland is wholly incapable of normal function. Since in such cases the changes in the nongoitrous thyroid are identical with those in the goitrous thyroid we must seriously consider if it may not also be cardiotoxic in the clinical sense.

In order to learn something of the structure of the thyroid gland which supposedly normal persons support I am now studying a large number of glands obtained from persons who have met sudden death by

accident or by disease not attended by constitutional reactions. We are wholly ignorant what changes, if any, are produced in the thyroid gland by terminal stages of chronic diseases, and therefore thyroids obtained from persons dead from lingering illnesses are not suitable for such study.

With these remarks we may leave the subject of the normal thyroid gland. We are not interested here in the structure of the acutely toxic gland, and may proceed with a somewhat detailed consideration of the degenerating gland and its effect on the heart.

#### DEGENERATIVE TOXIC GOITER

If we begin our study with the early colloid goiters we find, first, an increase in the colloid, which causes the enlargement of the gland, and an associated flattened epithelium. An increase in the number of acini usually is associated with the increase of colloid in causing the enlargement of the gland and may even play a predominant part.

At the early stage of enlargement there is no evidence of constitutional disturbances, but soon the goiter begins to show definite progressive changes. These are first apparent in the tinctorial changes of the colloid before there is any obvious alteration of the acinal cells. In many colloids there are areas of apparently newly developed acini. The presence of these is signaled by the presence of the symptoms of toxicity. This toxicity as is generally recognized is never of the type nor of the degree seen in Graves' disease. The toxicity is more variable than in Graves' disease. It is these variations in toxicity that are associated with the changes in cell hyperplasia. These nervous variations are independent of the effect on the heart. Even so it is often difficult to say which is dominant, the nervous or the cardiotoxic, until one has compared the microscopic structure of the gland with the clinical picture.

The recessions in nervousness and intervening recuperation may continue for

many years. Ultimately the entire organ becomes wholly degenerated and there remains no normally functioning gland. The rate of development of these changes is uncertain and variable. Generally speaking one can reckon the ultimate state in decades. It is equally certain the beginning of the changes occurs relatively early in the life of the goiter, long before the constitutional changes are usually recognized. The time when the clinical stage is reached depends more on the individual clinician than on the manifestations of the disease.

*The Cardiotoxic Goiter.* In the study of the cardiotoxic goiter patients it is convenient to divide them into the early and the late stages. The earliest stage is that in which the symptoms are not clearly defined, a preclinical stage to the majority of practitioners. In the late stage, when even grandmother can make a diagnosis definitely, the patient is suffering from a decompensated heart. Of course there is no dividing line, the one passes into the other so that looking backward one cannot say, even within a year or two, when one becomes the other. Each of these stages may be considered both clinically and pathologically.

*Early Cardiotoxic Goiter.* The clinical aspects of the early stages usually present themselves as more or less nervousness, perhaps some loss of weight before cardiac disturbance, increase in rate or intensity of beat, even to disturbance of rhythm. Loss of weight may be alternated by a gain. Increase of nervousness may exhibit ups and downs, perhaps nervous breakdown of greater or less degree. It is designated a nervous breakdown when the patient goes to bed for several weeks or months. The busy child-bearing women are prone to ignore such minor disturbances in view of the larger complaints, notably a husband and a lot of children. To the old doctor such goiters were innocent.

These symptoms become impressive only after one notes the disappearance of them following ablation of the thyroid gland. Women comparing sensations, when leisure

permits, discover that their sisters have been relieved of like complaints by the removal of their goiter. They seek the surgeon literally decades earlier than their less fortunate sisters of a generation ago. Naturally the surgeon, hearing expressions of gratitude from these patients after operation, became more alert in the discovery of the early stages of the disease. Thus a happy cycle is completed.

Pathologically the gland in this stage is usually obviously enlarged, often bosselated. Usually there is an increase in density. But, as intimated above, the presence of a goiter is not an essential part of the clinical picture. The thyroid gland need not be palpable at all. The diagnosis must be made from the history and examination of the patient, particularly the heart, before the neck is investigated. That is to say, one must be able to recognize the presence of a thyrotoxic cardiac state without evidence of thyroid enlargement. That is the essential factor. The recognition of pathologic states without physical evidence is as important in the case of the thyroid as is the recognition of intestinal obstruction due to a constricting cancer before there is any evidence of malignancy. The absence of a palpable gland is particularly common in plump women and husky middle aged men. The reason is that the gland is hidden by overlying structures.

The histology of this stage may be confusing. Compensatory hyperplasia may be associated with obvious degeneration. Hematoxylin and eosin stain may show little obvious change in the colloid and if the gland be not enlarged it may be regarded as anatomically normal. Of course when these patients show spells of toxicity this is expressed in the greater activity of the cells, but they never approach the changes of the acutely toxic goiter.

Such areas of cell hyperplasia are associated with areas showing colloid degeneration. A careful microscopic study will show areas of wholly atrophied cells, and very likely there will be acini showing a beginning basophilia. It is in these cases that the

use of other stains is mandatory. With Mallory's aniline blue stain, the staining of the colloid by the aniline blue is lost and the orange G stains become dominant. In acini in which the latter stain functions, the epithelium is obviously permanently out of commission. A tinctorial study of the colloid throws a great doubt, to say the least, on the theory of acting and resting cells. The resting cells will never work again.

*Late Cardiotoxic Goiter.* In the late stage the goiter heart justifies its name. Heart symptoms dominate; arrhythmia, dilatation, dropsy, from the usual order. The patient has a sense of exhaustion rather than the nervousness of the early stages. The sleep is disturbed but less from nervousness than from cardiac disturbances and dyspnea. The loss of weight may be slight but it may be marked. Dropsy—even generalized anasarca—may dominate the picture if the heart is in a state of utter decompensation. Many of these patients have been taking digitalis for long periods, despite which they sleep, if at all, sitting up. The terminal stages are usually those of a progressive heart failure, but sometimes there is a terminal hyperpyrexia.

The pathologic changes in the goiter in this stage are perfectly obvious. Usually there is evident thyroid enlargement but by no means always. It may be so slight that the physician has not noticed it, likely has not looked for it. In most cases, however, there is notable enlargement so that the goiter cannot be missed. The gland is usually irregular in outline indicating that acinar hyperplasia has been pronounced.

Even in the stage of marked decompensation the patient may recover fully after the removal of the goiter. The heart symptoms, it would seem therefore, are due to a poisoning from the goiter rather than to any degenerative change in the heart muscle itself. Somewhere in thyroids of this kind, we may conclude, something harmful is being produced. It is a toxicity of degeneration. We must conclude this

because the only changes present are those of degeneration. Just what is going on is impossible to say. Many of the cells are wholly degenerated. Whether other cells are still producing a poisonous substance or if the colloid is collected as in a reservoir and is absorbed slowly in the passing years is at present impossible to say. Likely the cells continue to produce an abnormal colloid, for one sees islands of cells which seem to be exerting a feeble effort at compensation. In rare cases these cells may be so active as to produce evidence of an acute intoxication.

Histologically there is but an exaggeration of the early stages. Usually the hematoxylin and eosin stain shows very obvious basophilic change. The epithelium is obviously degenerated and the connective tissue usually has lost its typical tinctorial reaction. It has taken part in the degeneration. The aniline blue stain shows the changes in the colloid at a stage when it still accepts the eosin stain. Many of the acini stain yellow with the orange G, refusing completely to take the aniline blue which characterizes the normal colloid.

The histologic study of the gland is important because it gives us a check on our clinical diagnosis. If the two do not correspond one must consider the clinical phases.

*Therapeutic Indications.* The most important thing for the surgeon to know is that the whole thyroid gland is affected in every case of goiter. There is no normal gland to leave. If he leaves in a piece of the gland he leaves a piece of the diseased tissue. He rids the patient of only a part of his disease. The patient is improved because a part is easier to bear than the whole. The tired hunter is refreshed if someone relieves him of the greater part of the weight of his duffle bag.

This being true, why does the surgeon leave any part of the goiter? Only because he is scared. In 1882 Kocher wrote a piece in a journal in which he called attention to the fact that total thyroidectomy may be followed by cachexia thyreopriva. His

## Hertzler—Goiter Heart

prize horror resulted after the total removal of a goiter from a boy aged 10 years, just at the advent of puberty. Kocher did not specifically state that this occurs only when this extensive operation is done in children. He did not note that when a total removal is done on adults no such dire results follow. He emphasized the dire results which followed removal of the whole gland in a boy 10 years old, but he failed utterly to note that no such results followed like operations on adults.

Extensive experience has proved that in adults we need have no fear of removal of all the thyroid tissue and thereby relieving the patient of all the gland that is poisoning him. This not only relieves him of his present trouble but assures him there will be no recurrence.

In this connection it is of interest to note what happens when total thyroidectomies are done in adults. My oldest totals are now more than eight years past and nothing unfavorable has happened yet. Now and then a patient seems to require thyroid extract for a while. The total removal of the thyroid gland in adults is not followed by dire results, let that be repeated. So much has been demonstrated, whether the physiologists like it or not. Some physiologists, let it be noted, recognize that when all of the thyroid gland is removed in fully developed dogs no terrible effects follow. Therefore they are not surprised when adult humans, when so operated on, do not experience dire results.

The timid still inquire about the end result of total thyroidectomies. First of all, what about postoperative myxedema? The development of postoperative myxedema is something like a religion. If one believes postoperative myxedema must follow total removal of the thyroid, presto, there it is. One can prove this, as well as anything else, by the B.M.R. These ritualistic surgeons are satisfied to give their patients very small doses of thyroid extract. These infinitesimal doses do the surgeon good and do not injure the patient. After an extended study I am prepared to show by case

records that myxedema is no more frequent than after partial operations. Myxedema is a mysterious state. It sometimes develops spontaneously, sometimes follows operations. Usually when it follows operation it persists for a time and then disappears. Sometimes it is more or less permanent over the years. Even so the taking of a grain of thyroid extract a day is not a very unpleasant procedure—no more unpleasant than the taking of a fried egg for breakfast. As compensation one may tell the patient that he is henceforward immune from goiter heart.

It is exceedingly difficult to determine just when postoperative myxedema is present. Of course if a patient has had a thyroidectomy and there is some sort of complaint, myxedema is often assumed, thyroid extract is at once given and if improvement follows of course the matter seems settled. However, it should not be overlooked that the vast majority of such patients recover if indifferent treatment is given, syrup of the iodide of iron, luminal or something of that sort. Certainly without the resort to thyroid extract.

It has been demonstrated, let it be repeated, that the total removal of the thyroid gland is not followed by dire results. But why the radical operation? The patients improve satisfactorily after the partial operation, at least in most cases. The reason is that the part allowed to remain may cause a goiter heart to reappear after five or ten or more years. I recently did a reoperation twenty-nine years after the first one. The occurrence of the goiter heart makes it mandatory to reoperate, not a pleasant task to perform and a humiliating thing if the patient presents herself to some other surgeon.

One may say therefore that it is no longer necessary for patients to die of goiter heart. Even more, we may say that they need not even suffer from it if the condition is recognized early and a radical operation is done. The live problem just now is to determine to what degree a nongoitrous thyroid gland may act the same way as a

goitrous gland. We might cease talking about the removal of the normal gland in cardiac diseases until we know whether or not the gland is normal. I venture to say that if a gland be normal its removal will not influence the heart in the least, and, conversely, if a cardiac patient is benefited by a total thyroidectomy, the gland was diseased. The disease may be demonstrated by a histochemical study of the colloid.

Patients who have once been relieved of a cardiac state are quick to recognize the recrudescence of the symptoms and present themselves for further observation. If an obvious recurrence of a palpable gland is present the problem is simple, but if there is no palpable evidence of a recurrence most surgeons hesitate to reoperate. Nevertheless if there is a recurrence of symptoms there must be a recurrence of gland toxicity and, feel it or not, one must proceed to remove it.

Perhaps the most common deterrent to a reoperation is the fear of the technical

difficulties. The difficulty of doing the radical operation is due to the failure accurately to locate and follow the line of cleavage. This can be done by sharp dissection. Fortunately there is always a line of cleavage to be found at the posterior capsule no matter how much scarring there may be about the front part of the gland. The difficulties now are not nearly so great as one might expect, provided one sticks to a sharp knife, avoids dull dissection and keeps his fingers out of the wound.

#### SUMMARY

The disappearance of cardiac signs following thyroidectomy is the most gratifying experience in clinical surgery.

It has been demonstrated that total removal of the offending goiter is a simple and safe procedure.

These facts make it mandatory that simple goiters be removed before the heart becomes affected.



# PNEUMONECTOMY FOR CARCINOMA OF THE LUNG

WITH REPORT OF A CASE

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NO field of surgery has advanced with such rapidity within the last decade as has that of surgery of the thorax; particularly is this true of surgery for carcinoma of the lung. Graham and Singer<sup>1</sup> in 1933 reported the first case in which a whole lung was successfully removed at one stage and this was for carcinoma. Since this time other successful cases have from time to time appeared in the literature. The number, however, is not great, so the recording of another such experience with a discussion of some of the problems involved seems timely.

A Japanese male, age 55, was referred by Dr. J. M. Kuhns from the island of Kauai on June 9, 1937. During routine x-ray examination of contacts of a tuberculous patient, a tumor involving the left chest of this individual was found. The patient had been absolutely asymptomatic and remained so during the course of observation. The first x-ray was made in September, 1936 and showed a round, apparently circumscribed shadow lying peripherally in the mid-portion of the left chest. Subsequent x-rays made in February and June (five months and nine months later), showed fairly rapid enlargement of the tumor so that at the time the patient came under our observation it approximated the size of a baseball.

General physical examination was negative. Wassermann and Kahn were negative. Stool and urine examinations showed nothing abnormal. Blood chemistry showed N.P.N. 41.8 mg. per 100 cc.; urea 14; creatinine 2.02; and sugar 93. Blood examination on June 10, 1937 showed: Hgb. 80 per cent; R.B.C. 5,160,000; leucocytes 6,800, with polys 76 per

cent, eosinophiles 9, monocytes 2, and small lymphocytes 13.

Blood count on June 12 showed: leucocytes 7,800, with polys 73 per cent, eosinophiles 5, monocytes 2, and small lymphocytes 2. On June 14 the leucocytes numbered 10,300, with polys 73 per cent, eosinophiles 11, monocytes 1, and small lymphocytes 15. Sedimentation rate was 43 mm. in one hour.

Air was introduced into the left pleural space as follows:

Date	Amt. of Air Introduced, C.c.	Cm. of Water
6-10-37	400	-4 -1 to -6 +7
6-12	500	-6 +2 to -3 +4
6-14	700	-6 -1 to -3 +4
6-15	300	-4 -2 to +2 +6
6-21	400	-4 -2 to +1 +5

Following introduction of air there was some collapse of the lung, but it was evident that the periphery of the tumor was attached to the chest wall and also that there were adhesions of the lung to the diaphragm and to the mediastinum.

Bronchoscopy was not done because the patient, being without symptoms, was reluctant to undergo examinations of an uncomfortable nature and we were afraid to urge them lest he refuse operation. It was also thought that such an examination would be of little if any value, due to the location of the tumor in the periphery of the lung. Thoracoscopy was also not done because of inability to secure sufficient pneumothorax space and for reasons previously mentioned.

From our examination we were in doubt as to whether we were dealing with a benign

or malignant lesion. The well circumscribed borders were in favor of the former and with 11 per cent eosinophiles, ecchinococcic cyst had

parietal pleura. There were also adhesions uniting the lower lobe to the diaphragm and to a lesser extent to the lower mediastinum.

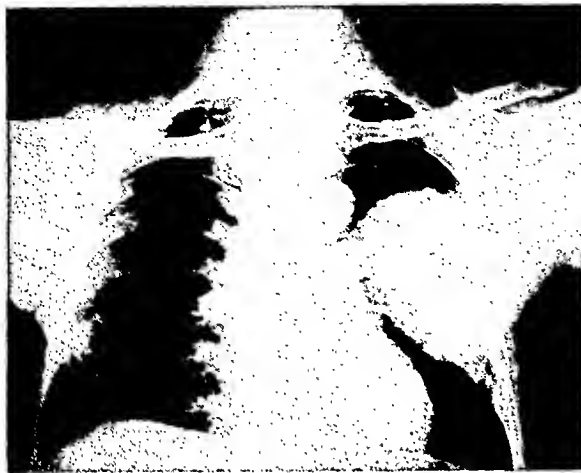


FIG. 1. Tumor of left lung, June 10, 1937.



FIG. 2. After pneumothorax, showing adhesions to chest wall, diaphragm and mediastinum.

to be kept in mind. The rapidity of growth and the patient's age suggested a malignant neoplasm and we were inclined toward this diagnosis by the statement of Tudor Edwards<sup>2</sup> who says: "In growths outside the main bronchus the characteristic radiological appearance is that of an opacity relatively uniform in density often rounded in outline and sharply marked off from the surrounding lung."

We were at least convinced that exploration of the chest was in order.

**Operation.** On June 24, 1937, under intratracheal cyclopropane anesthesia the approach to the tumor was made as follows: An incision beginning opposite the spine of the scapula, midway between the scapula and the posterior spinous processes was carried down and around the tip of the scapula to the anterior axillary line. Osteotomy, with removal of short pieces of the third, fourth, fifth, sixth and seventh ribs, was done a short distance from their attachment to the transverse vertebral processes. The intercostal vessels were ligated and a longitudinal incision made into the pleura between the ends of the severed ribs. An intercostal incision was then made anteriorly from the first incision to the anterior axillary line between the fifth and sixth ribs. Retraction of the chest wall between the severed ribs then gave an excellent exposure of the entire left thoracic cavity.

The tumor was found lying in the base of the upper lobe, intimately adherent to the upper part of the lower lobe and adherent to the

It soon became evident that in order to remove the tumor entirely, a complete pneumonectomy would have to be done. The hilus was freed of adhesions and the mediastinal pleura dissected away. Two curved clamps were placed as far medially as possible on the hilus and one distally, and the pedicle of the lung was severed between. The pulmonary vessels were ligated separately from the bronchus and en masse after the bronchial mucosa had been carbolized. Heavy chromic catgut was used. It was found impossible to cover over the stump of the bronchus because of inability sufficiently to mobilize the surrounding mediastinal pleura. The lung was then removed after separating the adhesions to the diaphragm and chest wall. A trocar was introduced at the lower chest margin in the mid-axillary line in the tenth interspace, and a No. 22 French Pezzar catheter was drawn from within out. The chest wall was replaced and sutured in layers with chromic catgut. The patient left the operating table in fairly good condition, pulse 110, blood pressure 80/60. Following blood transfusion and intravenous saline the blood pressure returned to normal.

**Pathologic Report.** The specimen consisted of the left lung, entire, with hilar lymph nodes. It was atelectatic from the partial pneumothorax. The upper and lower lobes were firmly attached to each other with the interlobar line of cleavage obliterated.

The lower two thirds of the upper lobe were completely replaced by a rounded tumor 9 cm.



in diameter, very well demarcated—even appearing encapsulated. On cut section it was found to be very necrotic and caseous, re-



FIG. 3. Apex to base section of left lung after mounting. On the left, apex; the sharply demarcated tumor occupies the lower two thirds of the upper lobe. The cross sections of the main bronchi are to be seen above as well as two large, anthracotic hilar lymph nodes, which did not contain metastases. (See article on "Museum mounting" by E. A. Fennel, *J. Lab. & Clin. Med.*, 23: 65, 1937.)

sembling a tuberculoma. It was divided into compartments by fibrous trabecula. Two hilar lymph nodes were markedly anthracotic. The lower lobe seemed unaffected save by anthracosis. The pleura showed no metastases, but only old adhesions.

Microscopically the capsule was seen to consist of collapsed and tightly compressed alveoli and pleura, the latter showing marked carbon deposits. The architecture was essentially alveolar—these faint alveolar markings suggested that they had been pulmonary alveoli or lobules, filled by tumor cells. The content of the alveoli was almost wholly necrotic, friable and caseous and only on the periphery were the neoplastic cells to be identified. The essential tumor cell was a very simple, atavistic, embryonal one—carcinoma simplex—and mitotic figures were very numerous and atypical. The lymph nodes showed no metastases.

The essential tumor cell resembled not at all the squamous type which so often arises high in the bronchial tree; it did not resemble the adenocarcinoma primary in the mucous glands nor did it resemble the transitional cell or oat cell carcinoma, so often primary in the lesser bronchi. Because it was so primitive and simple, because it resembled the lining cell of the terminal bronchi and because the tumor, when first discovered, seemed so peripheral, it is assumed that it was primary in the lining cells of a terminal bronchus.

The sharp delineation and the failure to involve the pleura or the adjacent lymph nodes indicated that the neoplastic process had probably been removed in toto. The prognosis accordingly appeared rather hopeful—at least more so than in most cases of pulmonary cancer.

**Postoperative Course.** The thoracotomy tube was sealed by placing the distal end beneath the bed in a bottle containing  $\frac{1}{5000}$  permanganate solution. The following day the patient complained of some respiratory difficulty. A pneumothorax needle was introduced into the left pleural space and pressure readings were found to vary between minus 2 and plus 2 with respiration. No air was added or removed.

On June 27, or the third postoperative day, there was again respiratory embarrassment with a rate of 48 per minute. The following note was made by the intern: "A pneumothorax needle was again introduced into the second left interspace in the mid-clavicular line; pressure reading 0 to plus 14. About 250 c.c. of air was removed and reading then was minus 12 plus 12. Then 100 c.c. of air was gradually introduced and the final reading was minus 6 plus 6. This seemed to be optimum for comfort."

Respiration at this time was 36 and pulse 100. Serosanguinous fluid began to appear after twenty-four hours and cultures of this showed at first a few short Gram-positive bacilli occurring singly and in pairs. The growth gradually became more profuse and the fluid had by the third postoperative week become definitely purulent. From the fifth postoperative day on, the thoracotomy tube was irrigated twice daily with Dakin's solution and only a few times did the patient complain of symptoms suggesting an open bronchus.

On July 21, approximately one month after operation, a left phrenic resection was done.

On August 4, a large sized thoracotomy tube was introduced higher than the original one by resection of the seventh rib. Due to rise of the diaphragm and shrinking of the chest cavity the original intercostal drainage tube failed to function properly, though it was left in situ and was used for irrigation purposes.

On September 14, eighty-two days after the pneumonectomy, considerable pus continued to drain from the residual empyema cavity. A first stage thoracoplasty was done, the three upper ribs being removed from the transverse spinous processes to near the sternum; this was followed by formalinization of their periosteal

beds. Though at the time little collapse of the thickened pleura was noted, x-rays taken one month later showed that a very satisfactory collapse had taken place.

compared with a decade ago. In our own Clinic Fennel<sup>3</sup> has found: "From 1920 to 1930 I did not see a single case of primary lung cancer. In the last six months I have



FIG. 4. Low power photomicrograph of tumor, to show, upper right, the thickened, anthracotic pleura, devoid of extension or metastases; lower left, the alveolar or lobular type of architecture. The central portion of each lobule is utterly necrotic and homogeneous; only on the periphery are the tumor cells to be identified.

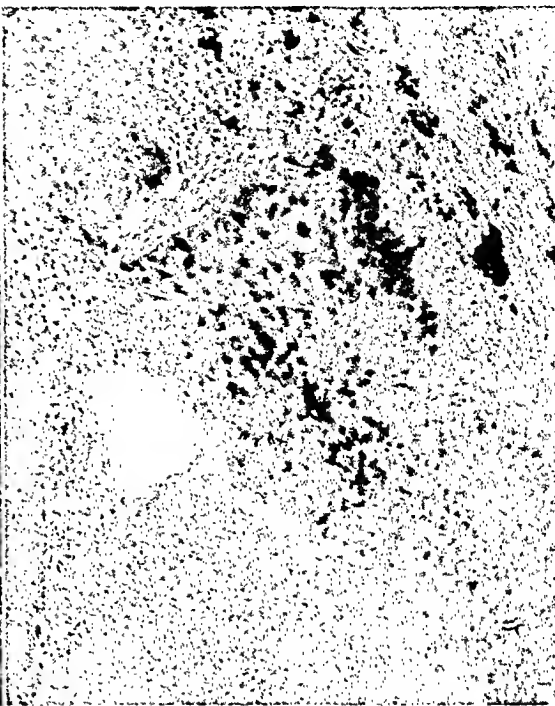


FIG. 5. A higher power photomicrograph of the right central portion of Figure 4, with pleura on upper right, marked necrosis on lower left, while in the center are to be seen the essential cancer cells, with many mitoses, one particularly conspicuous and large.

The patient was discharged from the hospital on October 11 (three and one-half months after the first operation) with his empyema cavity still unclosed, but the amount of purulent discharge considerably reduced. It was felt that since a rather stormy postoperative course followed the first stage thoracoplasty, a considerable time should elapse before doing more, especially since he was comfortable; four more ribs would probably have to be resected to close the cavity and there was probability of recurrence of the malignancy sooner or later. At the date of last report, February 1, 1938, (eight months postoperative) the patient was doing well.

It is difficult to account intelligently for the increase in the number of primary cancers of the lung now being diagnosed, as

seen eight cases." It seems scarcely possible that our diagnostic acumen should suddenly reach such perfection as to account for these findings. On the other hand Graham<sup>4</sup> does not believe that there has been an actual increase in carcinoma of the lung but that better diagnoses account for the greater number recognized even at autopsy. He believes that small lesions causing bronchial obstruction, lung abscesses, brain abscesses, etc., were formerly overlooked. Be that as it may, one cannot disregard the observations of the same author when he says that bronchiogenic carcinoma comprises from 5 to 10 per cent of all carcinomas and that they are diagnosable in 75 to 80 per cent of cases. Alexander<sup>5</sup> says, "Numerous patients are

still being referred to the surgeon and bronchoscopist in the inoperable rather than the operable stage because too few

signs of atelectasis beyond, as evidenced by dullness on percussion, absence of breath sounds, generally diminished vocal reso-



FIG. 6. Dorsoventral x-ray after first stage thoracoplasty and after resection of left phrenic nerve.

physicians at present realize that carcinoma of the lung is a relatively commonplace disease in middle age as well as in old age, and that mild pulmonary symptoms which are not diagnostic of other diseases may be the expression of an early phase of bronchial carcinoma demanding at once roentgenograms and bronchoscopy."

Quoting again from Graham and Tudor Edwards<sup>6</sup> they find the symptoms of early lung cancer in the order of frequency to be:

Graham	Tudor Edwards (Based on seventy-three cases)
1. Cough	1. Cough (Frequently non-productive) present in every case but one.
2. Chest pain or discomfort	2. Sputum (65 per cent). Usually mucoid, at times purulent.
3. Dyspnea	3. Hemoptysis (87.7 per cent). Does not appear to depend upon amount of non-functioning lung.
4. Sputum	4. Dyspnea (74 per cent).
5. Hemoptysis or streaking	5. Pain (60 per cent).
6. Chest colds	

Briefly, the clinical signs vary with the location of the lesion and with reference to the degree of bronchial obstruction. If the bronchus is obstructed one expects to find



FIG. 7. X-ray taken February, 1939.

nance with displacement of the mediastinum towards the affected side. Later there may be signs of pleural effusion, usually serous in character, but not rarely blood stained.

When the lesion arises peripherally, such as in the case we are reporting, physical signs may be absent or only a small area of dullness may be elicited.

The two procedures that are of chief diagnostic value are x-ray and bronchoscopic examination. Other examinations that may shed light on the situation included bronchography, diagnostic pneumothorax, examination of pleural fluid and sputum, thoracoscopy and exploratory thoracotomy.

By fluoroscopy one may be able to determine the relationship of the lesion to the hilus, to observe whether or not expansile pulsation is present, to observe the movements of the diaphragm and determine the presence of fluid. All oblique views are also easily obtained with the fluoroscope. Tudor Edwards has observed that

immobility of one side of the diaphragm strongly suggests metastasis involving the phrenic nerve on that side.

accessible for removal of tissue. Graham<sup>7</sup> also says, "There should be no hesitancy about making a positive diagnosis if the

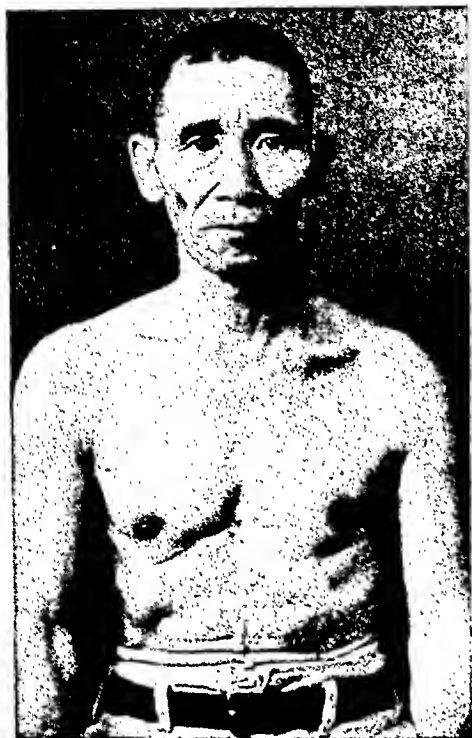


FIG. 8. Photograph of patient, February, 1939.



FIG. 9. Lateral view.

While x-ray films are of the utmost diagnostic importance one must ever bear in mind that the Roentgen ray appearance is due not only to the tumor itself but also to the effects of bronchial obstruction; namely, atelectasis, bronchiectasis, pneumonia, abscess of the lung, gangrene or obstructive emphysema. The primary tumor may be small, but if it is strategically placed in the bronchus, the results of the obstruction may be widespread.

In addition there may be metastasis to the bronchial or mediastinal glands, thickening of the pleura, pleural effusion or distortion of the mediastinum. It is readily evident then that while x-ray examination is important it is frequently not specific and other methods of examination must be relied upon to establish the diagnosis in many if not most instances.

Bronchoscopic examination in the hands of one competent and experienced will permit of a positive diagnosis of carcinoma if the lesion presents in a bronchus that is

patient is of the cancer age and if definite narrowing of the lumen of the bronchus and fixation and distortion of the carina is noted, particularly if these findings become more marked in the interval between examinations."

Diagnostic pneumothorax, if adhesions do not prevent pulmonary collapse, will enable one to tell whether the tumor is intrapulmonary or extrapulmonary. Examination of pleural fluid has in certain instances proved of value. Goldman<sup>8</sup> reporting on fifty effusions examined by the method of Mandelbaum, in which the centrifuged sediment is hardened and sectioned, reported 80 per cent positive diagnosis in twenty cases of proved malignant disease. Sputum should also be examined to assist in ruling out tuberculosis and certain fungus infections.

Thoracoscopy, when sufficient pneumothorax space is obtainable, may prove of value, particularly in recognizing pleural spread. Matson has recently called attention to this method of diagnosis. He states, "Thoracoscopy is undoubtedly one of the most neglected diagnostic procedures in clinical medicine. In the differential diag-

nosis of intrathoracic neoplasm thoracoscopy will give information otherwise unobtainable. While thoracoscopy is of great value in establishing a diagnosis of lung tumor, it is of particular significance in the differentiation of those primarily of the pleura with metastasis to the lung or vice versa. If the lung is sufficiently collapsed complete visualization and study of the pleural cavity can be made provided very broad or extensive adhesions do not obscure certain areas. In any event a definite diagnosis of the tumor type can be made before operation, either by the thoroscopic image grossly visualized or by the study of the biopsy specimen. In the case of mediastinal tumors valuable information may be derived regarding the nature of the mass, as well as its relationship to the important anatomical structures and the probable difficulties of its excision."

Recently we<sup>9</sup> found inspection of the pleural cavity by the thoracoscope to be of corroborative value in diagnosing a removable teratoma of the mediastinum. In determining the operability of the condition evidences of metastases should be looked for. Briefly these consist of immobility of the trachea as noted by the bronchoscope, mediastinal fixation and widening of the carina, and mediastinal widening as noted by the x-ray.

As previously noted, paralysis of one side of the diaphragm in addition to the above is good evidence of mediastinal involvement. Inspection of the pleura for evidence of spread has been mentioned. Biopsy of any enlarged cervical glands should be done as well as skeletal x-ray for metastatic deposits.

Exploratory thoracotomy may be the procedure necessary to establish the diagnosis; frequently it is the final step in determining the operability of such lesions.

There are a number of points to be considered regarding the operative technique and the methods of procedure when the individual suffering from carcinoma of the lung is considered to be a fit candidate for surgical interference. Most everyone

seems to agree on the value of preoperative introduction of air into the pleural space when feasible. By this method collapse of the affected lobe is gradual, the pleura becomes tolerant to the contact with air, the affected lung is more completely emptied of secretions prior to manipulation of the organ, the intrathoracic circulation has the opportunity to become adjusted to changes in atmospheric pressure and mediastinal shift, and the functioning ability of the opposite lung can be more accurately determined. Overholt<sup>11</sup> states that it is his custom to bring the intrapleural pressure to about plus 1 or plus 2 cm. (water) for a minimum of ten days preoperative.

Regarding anesthesia, intratracheal cyclopropane is reported by most observers being the method of choice at the present time.

Other points on which unanimity of opinion has not been reached include the following:

1. What shall be the method of approach?
2. Will the operation consist of the removal of a single lobe, two lobes, or complete removal of the lung?
3. Is it best to do a massive ligation of the hilus, or shall the structures be ligated individually?
4. What method of caring for the bronchus has proved most satisfactory?
5. Shall the pleural space be drained?
6. What steps if any should be taken to obliterate the residual pleural cavity?

In the approach to the lesion the methods most commonly described have been the lateral one, as used in our case, which corresponds to the technique as described by Overholt,<sup>11</sup> or the anterior approach which for priority of use belongs to Archibald.<sup>12</sup> The advantageous of the anterior approach as described by Overholt are that: (1) it provides the shortest approach and gives the most direct exposure of the mediastinum; (2) the question of operability can be settled without the necessity of mobilizing the lungs; and (3) the structures of the hilum are more accessible.

Undoubtedly the approach to a lung lesion corresponds to the method of approach to an abdominal lesion—that one should be used which fits the individual case. Certainly the exposure obtained in our case left nothing to be desired and I should hesitate to change the method of approach if and when a similar occasion arises.

In ligating the structures of the hilus considerable ado has been made as to whether one should ligate en masse or deal with each structure individually. Here again the exigencies of the situation should dominate the procedure. In general, individual ligation permits the job to be done in a safer manner with less likelihood of slipping of ligatures and with better opportunity of caring for the bronchus and permitting a cleaner dissection of surrounding glands. It is also acknowledged that mass ligation may be desirable when there is much inflammatory reaction around the hilus, making the isolation of individual structures difficult.

In dealing with the bronchus, most observers advise cauterization of its interior with either phenol or silver nitrate, closing it off by either ligation or suture and attempting to bury this structure by closing it over with surrounding tissue, usually mediastinal pleura. In our case there was nothing with which to cover the bronchial stump. Carbolization of its interior and ligation with chronic catgut were all that could be done.

Graham, in his textbook, says that various methods have been used in closing the bronchus, but most of them fail. He believes that it is good practice to sever the cartilagenous rings to prevent their springing back into position. He points out that if the bronchus can be prevented from opening for a week the results are less serious because the pleura is more resistant and the pleural space has become more restricted. It is also a recognized fact that most deep seated bronchial fistulae close spontaneously as a result of scar tissue formation and retraction.

There is a difference of opinion regarding the advisability of draining the pleural cavity. Graham says, "Because of the strong probability that the bronchial stump will open again spontaneously regardless of what method has been used to close it at the time of operation, we believe that drainage through an air-tight catheter should always be provided after the removal of either a whole lobe or a whole lung." He is of the opinion that it is not only wise to drain to prevent a tension pneumothorax in the event of the bronchus opening but in order to drain off the large amount of fluid that accumulates. This is also the opinion expressed by Archibald. Overholt says, "If the entire lung has been removed and if there has not been contamination of the pleural space, drainage is not used. In all lobectomy cases and after pneumonectomy with soiling of the pleural cavity, closed tube drainage is provided." Rienhoff and Broyle<sup>13</sup> on the other hand advise against drainage and state that the accumulated fluids assist in obliterating the pleural cavity.

If one could prevent tension pneumothorax and infection developing, closing the thorax tightly would seem indicated but probably more good than harm will come from instituting closed intercostal drainage routinely.

The advantage of pneumonectomy over lobectomy in the treatment of carcinoma of the lung seems apparent in view of the comparative safety of extirpation of this organ. The ability completely to remove the glands surrounding the bronchi and to carry the dissection into the mediastinum would seem to compare with results to be expected from simple mastectomy versus radical removal for carcinoma of the breast.

The necessity of surgical intervention for obliteration of the residual cavity left by removal of the lung has been the subject of much discussion and apparently depends upon whether or not the cavity becomes infected. The introduction of drainage following removal of the lung will undoubtedly in the majority of instances result in



pleural infection. A chest closed tightly in which subsequent opening of the bronchus occurs will undoubtedly result in a similar complication, though Rienhoff has reported instances in which the chest was closed tight, infection did not result and subsequent thoracoplasty has been unnecessary.

At least one point is agreed upon and that is that obliteration of the cavity by thoracoplasty is a procedure that can be postponed for some time after the pneumonectomy. It is not to be done at the time of the primary operation because of the added risk. An intact rigid thoracic cage offers better protection to the mediastinum than a chest wall devoid of ribs. Nature tends to obliterate the cavity by thickening of the pleura and retraction of the chest wall, by coagulation of serum with organization of the clot, by rise of the diaphragm and shifting of the mediastinum. Permanent paralysis of the diaphragm should be achieved on the side of the lesion as soon after the primary operation as the patient's general condition permits. This is usually a very minor procedure and well tolerated unless the patient is unduly apprehensive.

#### CONCLUSIONS

While surgery for carcinoma of the lung is a relatively new field, enough data and experience have accumulated to enable one to assume a rational attitude when confronted with such a problem.

First, the profession should become carcinoma-of-the-lung-conscious and make the necessary examinations which are now available to rule out or confirm the presence of malignancy when any obscure chest condition is encountered, particularly in

the age group where it is most common. Second, it should be realized that most malignancies of the lung originate in the stem bronchus and rarely cast a shadow unless complicated by bronchial obstruction. The x-ray picture may be misleading to the unwary, but the bronchoscopic examination usually establishes a correct diagnosis. Third, peripheral lesions may have the appearance of benignancy, but if doubt exists as to their nature after the methods of diagnosis previously discussed have been employed, exploration should be done.

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# PNEUMATOLOGY

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THE chief function of medicine is to save life. The accomplishment of this function often takes weeks, sometimes months, occasionally years. A life saved may be, and often is, crippled by the effects of the disease, or the accident which threatened it. It is rare that the man exposed to sudden death from physical causes is able to resume his ordinary duties a few hours after exposure. Yet this is the unique field and the reward which may be expected when we prevent asphyxial death.

Integration, the assembly of related information and activities, is the spirit of the times. The formation of special societies for every tiny phase of medical investigation and practice is to be deprecated. The field which proposes numerous problems tied together by a common bond, attracts a larger personnel often better qualified because of a wider outlook. It justifies more equipment and is more economical to operate than is the sharply circumscribed speciality limited to an anatomic region.

The purpose of this paper is to suggest just such an economical, effective integration in the field of gas therapy.

It is proposed, therefore, to assemble under a generic terminology, three fields, logically associated by the common bond of the therapeutic use of gases—gases for the control of pain, for the saving of life, and for the treatment of clinical disease. Since the most important function of the physician is the saving of life, it is logical that the use of gases for the prevention of asphyxial death should take first place, regardless of the fact that the total volume of this activity when compared with the control of pain is relatively insignificant.

What is asphyxial death? What are the causes of asphyxial death? Viewed clinically, asphyxial death may be described as, "a deficiency of available oxygen in the

circulating blood, terminating fatally," or more simply, "oxygen want, causing death."

Asphyxial death is to be distinguished from the terminal phenomena of asphyxia which frequently brings about death due to disease or accident. The distinction is clear when regarded from the point of view of relief. Asphyxial death may be prevented and the victim returned to normal health, if suitable resuscitation measures are employed. On the other hand, successful treatment of asphyxia occurring as a terminal complication in sepsis, cerebral hemorrhage, etc., merely postpones, but does not prevent the fatal issue.

With a view of assembling the common causes of asphyxial death any one of which might be expected to yield to adequate resuscitation measures, correspondence was established with departmental heads of Physiology, Pathology, Toxicology, and Forensic Medicine at Cornell, Leland Stanford, Johns Hopkins, Bellevue, Harvard and Yale Medical Schools. As a result of these inquiries, the following causes of asphyxia have been assembled:

1. Asphyxia neonatorum.
2. Asphyxia from gases, used industrially.
  - (a) Carbon monoxide from illuminating gas and from engine exhaust, coke and coal fires.
  - (b) Refrigerants such as ammonia, carbon dioxide and dry ice.
  - (c) Fumes in the manufacture of chemicals.
  - (d) Gases associated with the oil industry.
  - (e) Gases in the mining industry.
  - (f) Fumigation for disease, the destruction of rodents on board ship and elsewhere.
3. Asphyxia from gases in warfare.

## Flagg—Pneumatology

4. Asphyxia from drugs, hypnotics, narcotics and sedatives, including acute alcoholism.

5. Asphyxia from disease, such as acute pulmonary conditions, asthma and cardiac decompensation.

6. Asphyxia from developmental and mechanical abnormalities, such as neonatal atelectasis and collapse of the lung.

7. Asphyxia from anesthesia due to overdosage, idiosyncrasy or a failure to meet mechanical obstruction, occurring in relaxation.

8. Asphyxia from submersion (drowning).
9. Asphyxia from flying at high altitudes.

10. Asphyxia from fire fighting (smoke, chemical poisoning).
11. Asphyxia from obstruction by foreign bodies.

- (a) Material caught in the esophagus or inhaled.
- (b) Tumors or infections within or without the airway.

12. Asphyxia from electrocution.
13. Asphyxia from strangulation, garrotting, hanging, broken neck.

14. Asphyxia from terminal poliomyelitis.
15. Asphyxia from suffocation such as overlying, suffocation with soft materials, such as pillows, etc.

16. Asphyxia from external pressure on chest and abdomen, occurring when patients are caught between two moving objects, automobiles, elevators, laundry machines, etc.

17. Asphyxia from collapse of buildings, earth mounds, caves, sand, fire coal in large coal mines, land slides.
18. Asphyxia in manholes, wells, and declivities in the ground, usually from lack of oxygen and increase of CO<sub>2</sub>, and sometimes from poisonous gases.

19. Asphyxia from polyneuritis, and from facial diplegia.
20. Asphyxia from polyneuritis, and from facial diplegia.

Employing the test of "common treatment" as the link which binds the fatal emergencies just enumerated, let us consider the statistical and social implications which such treatment implies.

The first fact brought to light is that we are face to face with a medical problem whose mortality is at least twice that due to automobile accidents. An estimate of 50,000 lives a year from asphyxiation, proposed six years ago, has been repeatedly corroborated. Laudable attempts to control this mortality, and to reduce it have been made by lay technical groups operating under the direction of industry, the utilities, and the municipalities.

The importance of the problem has been largely overlooked by physicians and hospitals' administrators for two reasons: first, the high mortality is not generally known, secondly, modern medical methods to meet the biochemical problem of acute asphyxiation are of comparative recent development.

The movement to prevent asphyxial death, however, is slowly gaining ground. The problem is attracting the attention of hospital administrators and lay boards, chiefly through attempts to reduce asphyxia of the newborn which constitutes more than 60 per cent of the total. The departments of obstetrics of the medical schools of the country are interested to formulate and to practice technique developed as the result of modern biochemical research.

Unfortunately, medical education and the policy of the hospital regarding the care of asphyxial emergencies has been mislaid and hampered by the activity of commercial interest in the field. These interests, intent upon the popularization of equipment carrying the name of manufacturer or inventor, have attempted to compress the intricate pathology of asphyxia into the narrow confines of rigid mechanism. The effect has been to reduce the consideration of a complex problem involving life and death to a level of mere commercial conflicts. It is clear that this confusion will continue to exist until there is a common acceptance of the fundamental principles which underlie diagnosis and the

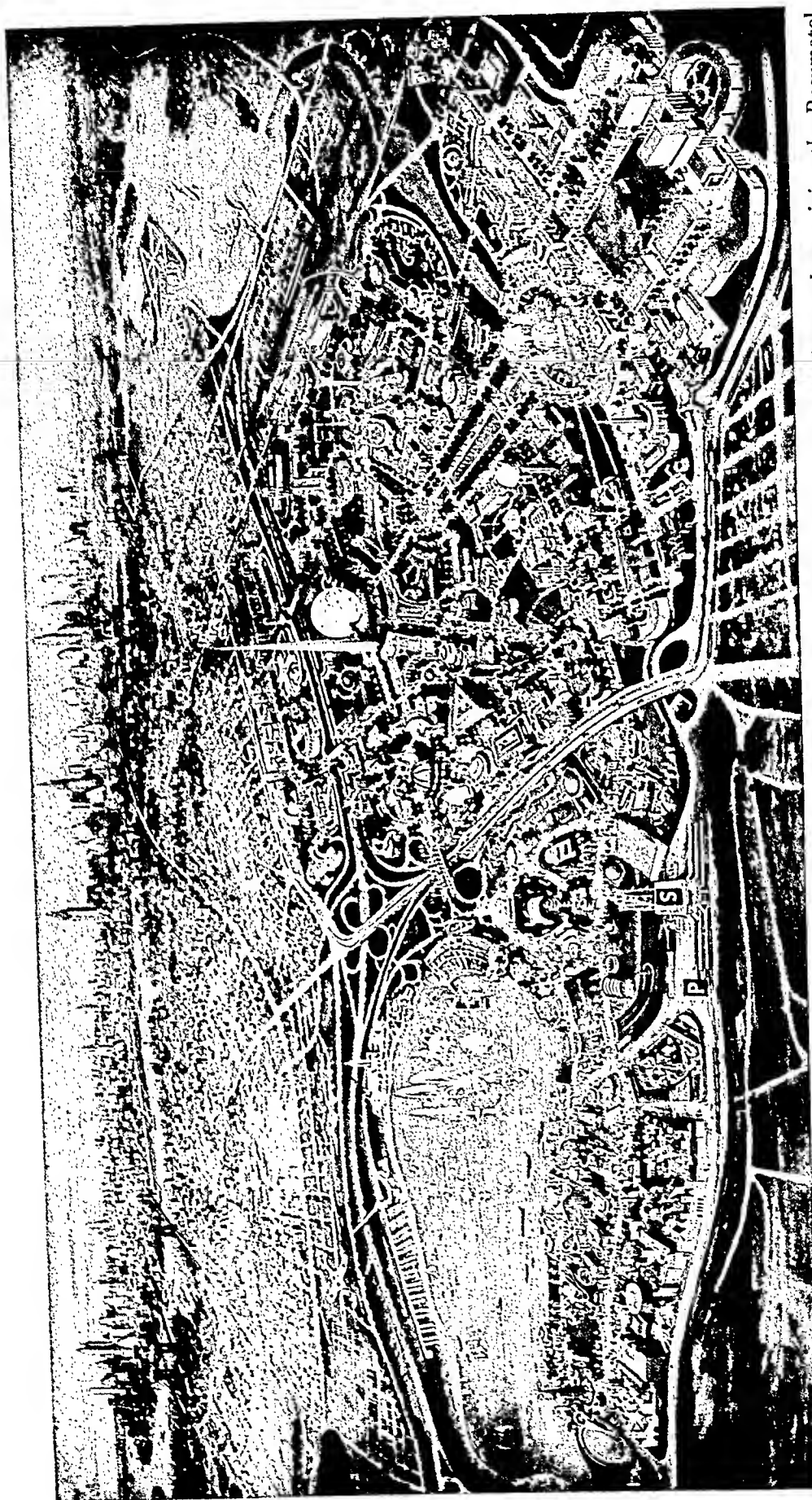


FIG. 1. New York World's Fair, 1939. S, independent subway station. P, long building housing one of first aid stations and containing the Pneumatology exhibit.

indications for treatment of the varying degrees of asphyxiation.

The Society for the Prevention of Asphyxial Death, the first non-profit charitable organization whose activity is limited to the prevention of asphyxial death, is largely responsible for setting on foot present interest in the subject. Through its efforts, the aims and purposes of which were approved by the American Medical Association, June 12, 1934, a committee on asphyxia was appointed by the Board of Trustees of the A. M. A. at the Kansas City meeting in 1936. In the fall of 1938, the Society was invited to coöperate with the Medical Department of the World's Fair with a view to organizing a department of pneumatology for the care of the Fair personnel and visitors, representing a daily attendance of more than a quarter of a million persons. One of the first steps of the Society has been to release a statement covering the principles governing the diagnosis and the treatment of various degrees of asphyxiation. The Society has recommended that the emphasis be placed upon the exact pathologic physiology presented, rather than upon equipment employed. It has suggested general principles of treatment in accordance with the specific indications presented by each case. Mechanical equipment for the use of the Fair will be approved on the basis of simplicity and the ease with which indications for treatment may be met. The statement of principles released by the Society are as follows:

"The successful treatment of asphyxia by mechanical and chemical means, after the immediate cause has been met, i.e., when the patient is removed from the water, and the electric current is shut off, turns upon the following factors: the stages of asphyxia; its physical signs; the indications for treatment and the technique and apparatus required.

"The stages of asphyxia are as follows: (1) *Depression*. Patient is unconscious, but may be roused. The vital functions are unimpaired. (2) *Spasticity*. Patient is un-

conscious and cannot be roused. Vital functions are embarrassed. (3) *Flaccidity*. Patient is unconscious, cannot be roused. Vital functions are seriously interfered with, or in abeyance.

"The physical signs of these stages are quite constant regardless of the cause of asphyxia.

"*Stage of Depression*. Patient is in a stuporous or semiconscious state. He may be roused by slapping the face, friction of the lip, etc., but usually relapses following stimulation. Reflexes active, respirations shallow and quiet, pulse regular may be depressed or stimulated. Patient may retch or vomit and move extremities.

"*Stage of Spasticity*. Patient completely unconscious and cannot be roused. He is cyanosed or pallid, depending upon the condition of the circulation. Breathing is obstructed, there is a tendency to maseteric spasm. Vomiting, and bleeding from the mouth or nose are common. Eyes are injected; skin is cold; pharyngeal reflexes active; extremities relaxed; circulation sluggish or with the bounding pulse of anoxemia.

"*Stage of Flaccidity*. The patient is completely relaxed. Jaws separate without resistance. Pharyngeal reflexes in abeyance. Skin cold and clammy. Eyeballs fixed, reflexes gone. Laryngeal reflexes sluggish or absent. Respiration shallow and obstructed, or not demonstrable. Heart sounds are inaudible. Patient cyanosed or pallid."

*Indications for Treatment of Each Stage. Mechanical Apparatus Required.* *Stage of Depression*. The condition suggests that treatment be directed to exposure and shock rather than to the specific relief of asphyxia. The patient should be given oxygen and carbon dioxide, because stimulation of the respiration results in the automatic stimulation of the circulation. Heat should be applied to the extremities and to the body. Patient should be placed on the side and provision made to care for nausea and vomiting. Hypodermic stimulation may be given to advantage. No

fluid by mouth should be permitted.

Apparatus necessary:

1. An inhaler with a bag near the face-piece.

2. Facilities for rebreathing.

3. Adequate supply of oxygen or oxygen-CO<sub>2</sub>.

*Stage of Spasticity.* The indications are to meet existing anoxemia promptly and to prevent aspiration of fluid or foreign matter into the trachea. Respiratory obstruction by clenched teeth or tongue interfering with the administration of oxygen should be relieved by the use of oxygen by nasal or oral tube, accompanied by the use of suction. Strenuous efforts to separate the teeth and to pull forward the tongue should be avoided because adequate oxygenation can be given posterior to the obstruction by means of the nasal catheter or the nasal tube. If the patient is breathing freely, however, without signs of respiratory obstruction, oxygen may be given by an inhaler. Apparatus required:

1. Pharyngeal tube.

2. Nasal catheter.

3. Adequate suction facilities for use in the throat.

4. Oxygen and oxygen-CO<sub>2</sub>.

*Stage of Flaccidity.* Relaxation of the muscles of the airway, disappearance of pharyngeal and laryngeal reflexes as elicited by suction and by oral tube, constituting positive indications for mouth-to-mouth insufflation, or better and much more effective, suction, laryngoscopy, intubation and endotracheal suction, followed by oxygen insufflated endotracheally for a period of five seconds, under pressure of 25 to 40 mm. of mercury. This treatment will maintain life by rescuing the respiratory center, and stimulating the herring bruer reflex providing there is a functioning circulation.

Coincidentally, with endotracheal insufflation, the patient should be given intracardiac injections of adrenalin, accompanied by intravenous metrazol or coramine. Apparatus required:

1. Laryngoscope.

2. Intubation tubes.

3. Endotracheal suction.

4. Oxygen and oxygen-CO<sub>2</sub>.

5. Pressure manometer.

6. Hypodermic solutions, facilities for intracardiac injections.

7. Heat for body.

Transportation facilities should be provided for treatment enroute, be it over the water or in an ambulance. There is no good reason to continue treatment at the site of the accident, when suitable equipment is provided. Upon return to the medical station, the patient should be hospitalized from twelve to twenty-four hours in an oxygen atmosphere, and facilities should be provided for treatment in a negative pressure cabinet whenever this becomes necessary.

The adequate care of asphyxial emergencies involves technical as well as medical groups. The technical groups comprise those individuals who in all but intramural emergencies make first contact with the asphyxiated patient. These groups include those under the control of municipalities, such as the fire and police departments, the industries, so well exemplified by the Bureau of Mines and many construction groups, as well as the utilities, including the gas and electric light corporations. Among the volunteer rescue squads are those of the Red Cross, Volunteer Life Saving Corps, Boy and Girl Scouts, and many others. The field of treatment of these technical workers lies distinctly within the stages of depression and early spasticity. The methods available to these groups do not cover, in an adequate manner, the urgent need of the patient in the later stages of spasticity and in the stage of flaccidity. Recoveries which occur in these extremes are more likely to be due to the patient's constitutional resilience than to the attempts of the rescue squad. While routine prone pressure Schaefer, Sylvester, and inhalator methods are by no means to be discouraged, in any extreme encountered in the absence of the physician, the point is to be stressed that these

methods cannot be expected to meet the patient's needs or to give him the best chances for recovery. The outstanding obligation of all rescue groups is to make every effort immediately to contact medical assistance when an unconscious asphyxiated patient is encountered.

Such calls for assistance to the medical personnel implies that it is qualified to bring additional methods to bear for the relief of the patient. Unfortunately, an intimate acquaintance with the needs of the unconscious patient in spasticity or flaccidity is at this writing possessed by a very limited number of medical men.

The situation can be tested in any average institution. If an unconscious carbon monoxide patient is brought to your emergency ward, who on your staff is acquainted with the problem and immediately available? If a patient in a medical ward suddenly develops respiratory failure due to idiosyncrasy to medication, who is to be called? If an emergency arises requiring the transportation of an ascending poliomyelitis with respiratory paralysis, who on your staff is prepared and familiar with the situation? If a postoperative nose and throat case becomes acutely asphyxiated due to foreign body obstruction, who is immediately called and prepared to give relief?

In these emergencies, the experienced hospital worker may or may not turn to the member of the staff most familiar with the care of the unconscious patient, the man whose duty it is regularly to induce unconsciousness for the control of pain, the anesthetist. The very terminology, anesthesia, indicating the control of pain offers resistance and limitation to the use of this resistance regularly encountered in the care of accidents calling for emergency treatment, but it is also present in the use of gases for the treatment of clinical disease such as pneumonia, cardiac decompensation, etc., usually referred to as oxygen therapy.

The question is naturally raised, why do not these fields function as one unit, under proper departmental organization? The urgent need of such organization in the relief of hospital morbidity and mortality will be appreciated by the medical board and by the administration. It is not only necessary but entirely logical that one department should be held responsible for the administration of gases for therapeutic purposes, i. e., for the saving of life (resuscitation), for the control of pain (anesthesia), and for the treatment of clinical disease (oxygen therapy).

The initiation of such an integration must come from the hospital administration, for it is only the administration, and the medical board which is fully qualified to judge the relative importance of these activities, one to another, and to the related work of the hospital. Philosophically, as a part cannot well grasp the whole, so anesthesia cannot be expected to activate the integration of these fields.

Furthermore, inasmuch as resuscitation and oxygen therapy promise little if any means of subsidy to the anesthetic personnel, this deficiency becomes the obligation of the general hospital budget.

While the anesthetists cannot be expected to integrate the fields of gas therapy, nevertheless such integration is out of the question without the active direction and coöperation of the anesthetic personnel. The head of the department of pneumatology should be a Diplomate of the American Board of Anesthesiology, or at least a qualified affiliate.

The terminology, gas therapy, is descriptive, but it is not scientific. For this reason, a search was made in the literature to discover an acceptable term to cover the use of gases for therapeutic purposes. The term pneumatology is already in use. It is descriptive, easily handled, and scientific. It covers pneumatics, the use of gases in their application to pneumon or the lung. Its derivatives, pneumotherapy, and pneumatologic technician are easily handled. In the words of the editor of the "Health



Officer," the official organ of the Surgeon General of the United States Public Health Service (November, 1937), "The terminology Pneumatology is recognized in medical nomenclature. It is suggested that the terminology be generally adopted."

The use of this terminology and its practical application in the New York World's Fair finds development in the invitation which the Society for the Prevention of Asphyxial Death has received from the Fair to set up plans for the development of the integrated fields of anesthesia, resuscitation, and oxygen therapy for the care of the Fair personnel. The plan of organization submitted is briefly as follows:

*Field of Operation.* Area of 1200 acres, greatest distance  $3\frac{1}{2}$  miles, including water hazards in private lakes and the Long Island Sound basin. Possible hazards for which protection is requested: Asphyxia from gases, drugs, submersion, fire fighting, foreign body obstruction, tumors within or without the airway, electrocution, strangulation, allergy, pressure due to moving objects, collapse of buildings, poisonous gases in manholes, and from the infrequent, but occasional, premature asphyxia neonatorum.

*Communication.* Elaborate communication facilities on shore are provided. Short wave radio communication from water craft specially equipped for submersion in connection with the New York Telephone Harbor Service is recommended. Such communication is necessary for the transmission of intelligence from and to water craft in the Sound basin. Asphyxial accidents are to carry the emergency call P. A. D. which is the S. O. S. of asphyxia.

*Transportation.* A fleet of ambulances, adequate for the purpose, is equipped with

the essentials for the care of the unconscious patient in transportation, suction from the intake manifold of the engine for both local and distance use, illumination, adequate air conditioning, mechanical conveniences for the treatment of the three stages of asphyxia.

Water transportation to cover the lakes and the Sound basin requires an open speed boat equipped in a manner similar to ambulances, for use on the Sound basin. Watercraft on the Sound basin are supplied with facilities for the safe removal of the submerged patient from the water aboard ship, with facilities for immediate treatment following removal from the water. Close coöperation between water craft and ambulance permits transportation of the patient to the chief medical station in which the department of pneumatology functions. The patient receives here the benefits of post-asphyxial treatment through the use of oxygen therapy by nasal catheter, oxygen tent, or negative pressure cabinets as indicated.

The division of pneumatology is fully equipped with gases in common use for anesthesia from minor surgical procedures. It consists of a large operating room for the care of asphyxiated patients and a recovery ward for post-asphyxial and postoperative treatment. It is suggested that the facilities available in this division provide matter for demonstration to hospital administrators. The division is in charge of an experienced anesthetist, thoroughly familiar with the management of the unconscious patient in anesthesia, and acquainted with the principles underlying the use of gases for resuscitation and oxygen therapy. Historical and other informative matter dealing with pneumatology is available to visiting physicians and those interested in the problems presented.





# THE DECLINE IN INCIDENCE OF TUBERCULOSIS OF BONES AND JOINTS

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ALMOST one hundred years ago it was noted by Phillips<sup>1</sup> that scrofula was much less prevalent than it had been during the seventeenth and eighteenth centuries. At the present time it is generally accepted that there has been a decrease in the incidence and mortality from pulmonary tuberculosis. The general death rate from all forms of tuberculosis has fallen from 400 per 100,000 in 1870 to 69 per 100,000 in 1936 among residents of New York City, Philadelphia and Boston.<sup>2</sup> The death rate from tuberculosis among children under fifteen years of age in New York City has fallen from 130 per 100,000 in 1900 to 12 per 100,000 in 1936.<sup>3</sup> On the basis of these mortality rates it is safe to assume, according to Edwards,<sup>4</sup> that there has been a marked reduction in incidence of tuberculosis between 1867 and 1937, although corroborative statistics are not available. Coincidentally there has been a marked decline in the actual number of patients affected with tuberculosis of the bones and joints who apply for dispensary care at the New York Orthopaedic Hospital. The results of a study of these patients covering the past seventy years are of exceptional interest to the entire medical profession.

In 1866 the New York Orthopaedic Dispensary and Hospital opened its doors for the purpose of furnishing treatment to the poor, with special reference to the diseases and deformities of the spine and hip-joint, and other of the more serious diseases of the bones and joints requiring surgical and mechanical treatment. The objectives of the institution have been maintained, with the result that the type of patient seen during the past seventy years has varied but little, and has been drawn

from uniform economic strata throughout. The Dispensary has served the patients of the city and surrounding environs during this period without restriction as to race, creed, age or sex, and is so organized as to allow continued observation of each patient from the day of application for treatment until discharged. If any operative procedures are carried out in the Hospital, an annual request is made for the patient to return to the follow-up clinic for subsequent examinations.

In order to explain the decreased incidence of general tuberculosis, economists and statisticians have devoted attention to a study of factors falling within the field of modern industrial development and the science of population.<sup>5</sup> The betterment of existence for large masses of people, the raising of the standard of living, improvement in measures of education and protection for workers, and the institution of numerous hygienic reforms has followed the industrial development of most civilized countries. This development has resulted in changes in population structure due to the declining birth rate and the increasing expectation of life. The work of clinicians, general practitioners and public health officers deserves the highest commendation in connection with the decreasing incidence of tuberculosis, although one such health officer<sup>6</sup> has expressed the belief that heredity, in conjunction with the law of survival of the fittest, is the real factor accounting for the universal and gradual decline in the death rate from tuberculosis.

Pasteurization of milk has undoubtedly exerted a marked effect in reducing the incidence of tuberculosis. Prior to its introduction in New York City, about

12 per cent of all samples of milk examined showed infection with tubercle bacilli.<sup>7</sup> All raw milk now sold in New York City is subject to very stringent examination and regulation, the bulk of the milk supply being pasteurized. For years the Health Department of the city of New York maintained the enviable record of never losing a legal case involving prosecution for the sale of adulterated milk. According to Park,<sup>8</sup> pasteurization furthermore effected a reduction in the incidence of tuberculous bone and joint lesions, especially in children, following its introduction in New York City about 1912.

TABLE I

PERCENTAGE OF CASES OF BONE AND JOINT TUBERCULOSIS (CHILDREN AGED 0-15) AMONG ALL NEW DISPENSARY PATIENTS, 1911-1936

Year	Percentage	Total Cases of Bone and Joint Tuberculosis among Patients 0-15 Years of Age	Total New Patients All Ages
1911	9.7	193	1,978
1912	7.5	166	2,210
1913	7.2	181	2,506
1914	6.0	165	2,767
1915	5.2	178	3,436
1916	3.3	148	4,482
1917	2.7	143	5,408
1918	2.8	206	7,381
1919	2.7	183	6,726
1920	2.4	169	7,028
1921	2.0	171	8,611
1922	1.5	137	8,912
1923	1.2	117	9,583
1924	0.9	83	9,439
1925	0.9	82	8,933
1926	0.7	59	8,301
1927	0.6	58	9,669
1928	0.5	49	8,929
1929	0.4	33	9,687
1930	0.3	31	10,078
1931	0.2	20	10,857
1932	0.2	18	10,562
1933	0.2	20	10,712
1934	0.2	19	11,006
1935	0.2	25	10,410
1936	0.1	12	10,156

Table I reveals that the incidence of bone and joint tuberculosis in children seen in the New York Orthopaedic Hospital has fallen during the past twenty-five years from 9.7 per cent to 0.1 per cent, with a

marked decline evidenced at the period of introduction of milk pasteurization. It must be pointed out that Table I is only a rough approximation of the incidence of bone and joint tuberculosis in children, but this estimate is the only one which it is possible to make from the available figures. It is an interesting commentary that fusion operations for tuberculosis of the spine and knee were first performed at this same period.

The decline of tuberculosis in general is related to the decline of this disease which starts in early life. Since 1907, there has been a decline of 88 per cent in the death rates from abdominal tuberculosis among infants.<sup>9</sup> Such a decline may hardly be presumed to be accidental, especially when it is considered that diarrheal diseases among infants have also declined since the institution of pasteurization of milk in New York City. In Brittany and Scotland, where sanitation is poor, all forms of scrofula, tuberculous glands of the neck, ulcers and multiple lesions, flourish, while these bovine forms have practically disappeared in the United States.<sup>10</sup>

The question has been raised as to whether adult pulmonary tuberculosis is frequently due to an endogenous infection from an earlier childhood disease, or whether it is almost invariably due to exogenous adult infection.<sup>11</sup> When there are local tuberculous lesions in organs of the body which are not accessible to outside infection, such as the bones, kidneys, lymph nodes, etc., there is no escape from the conclusion that they occurred from blood stream dissemination.<sup>12</sup> The appreciation of the fact that almost all extrapulmonary tuberculosis is due to a systemic hematogenous infection and that such infection must also reach the lungs, would lead the physician or surgeon called upon to treat localized tuberculosis of the bones, joints, ischio-rectal fossa or kidney, immediately and searchingly to investigate the lungs, where often lesions may also be found, although frequently they give no symptoms.<sup>13</sup>

The childhood type of pulmonary tuberculosis is not confined to children, and the danger of development of hematogenous forms of tuberculosis lasts into adult life. If cases of this sort are recognized as possible sources of active tuberculosis, there can be no doubt that many of the advanced forms of the disease could be prevented.

The whole campaign in child hygiene has placed special emphasis on children with tuberculous tracheobronchial lymph nodes who respond positively to the tuberculin tests. These children must have more rest than the normal child; their activity is restricted; they are given a protective environment with more out-of-door life and artificial or natural heliotherapy; and special attention is paid to their diet and the improvement of their nutrition, with the addition of vitamins, particularly of vitamin c in the form of tomato juice, and vitamin d in the form of cod liver oil or some of its derivatives. Not only is there less tuberculous infection, but also tuberculosis is less active in children. Thus the campaign against incipient tuberculosis, by controlling the pulmonary form, indirectly affects the bone and joint incidence.

Government inspection of meat has eliminated the sale of grossly infected meat from tuberculous cattle, swine and poultry. Even more important has been the supervision of dairies leading to the production of a cleaner milk supply, and the destruction of infected cattle. Indemnity for condemnation of cattle has been paid in New York State since 1867, and 960,000 cows have been condemned and killed in the state since May 1918. An annual appropriation of \$450,000 is made for the testing of cattle in the State of New York. During 1936, 1,500,000 cattle were given tuberculin tests and 2,185 of these animals were found to be positive reactors.<sup>14</sup> Comparable control is being carried out throughout the United States and its possessions by the Tuberculosis Eradication Division, Bureau of Animal Industry, United States Department of Agriculture.

Trudeau Sanatorium at Saranac Lake, New York, has led the way in demonstrating the value of the control of patients infected with tuberculosis. Segregation of tuberculous patients, whether at home or in sanatoria, has led to the proper control of probable sources of infection by lessening exposure. Careful supervision and training of the patient who is confined at home assures the destruction of sputum, and an attempt at isolation from contacts with other members of the household. The use of sanatorium facilities in the treatment of tuberculosis is applying the principle of isolation with respect to a communicable disease and the education of such patients has laid the foundation for an intensive preventive program among families and contacts. Physicians trained at Trudeau have been pioneers in establishing sanatoria throughout the United States, and this important factor in tuberculosis control is now universally recognized as evidenced by the increasing number of sanatorium beds available in each state.<sup>15</sup>

It is upon the work of clinicians, practitioners and public health officers that the basic structure of the program against tuberculosis has been founded, notwithstanding the diversity of its ramifications. Various other factors involving engineering, enactment of legal measures, transportation, and industrialization have been utilized, to the benefit of general medicine as a whole. Sanitary engineering, aided by legislative measures, has eradicated the congested housing of many slum areas and improved the hygiene of the home by modern methods of lighting, ventilation and sanitation. More rapid means of communication and better knowledge have made vitamin-bearing foodstuffs available practically throughout the year. Contrast the ward patients of today who receive between meals extra rations of fresh fruit, dietary carbohydrate deficiency was made up by the use of molasses. Undernourishment is seen less frequently in the New York Orthopaedic Hospital patients of the

present time, which may well be of significance in the decline of tuberculosis.

Removal of foci of infection generally has been increasingly stressed in the care of the patient, leading to improved bodily resistance of the individual. Duncan<sup>16</sup> has recently reported the presence of tuberculosis in 24 per cent of tonsils removed from 100 patients treated for joint tuberculosis at the New York Orthopaedic Hospital.

Education of the public through the schools, by means of the radio and the press, and in preventoriums has been another factor of major importance in the field of tuberculosis epidemiology, leading to adequate screening, better hygiene and a greater degree of cleanliness in the home. Improved surgical methods, more especially thoracoplasty, pneumolysis, pneumothorax and oleothorax, have brought about arrests for many thousands of patients with pulmonary tuberculosis. Sterilization in such pulmonary cases lessens the period of infectivity of these patients.

The treatment of bone and joint tuberculosis with fusion operations is an important factor in the continuing decrease in the duration of activity of tuberculous bones and joints. Arthrodesis of the affected joint removes a dispensary patient from circulation among the hospitals of a metropolitan area by arresting the lesion. Thus the number of patients seen in any one hospital will be lessened the more frequently these tuberculous joints are cured by adequate fusion.

There are also many factors contributing to the control of bone and joint tuberculosis. Early diagnosis and prompt treatment have resulted in better care for the dispensary patient who presents a tuberculous lesion. The use of roentgenography, cutaneous reactions by the von Pirquet and Mantoux tests, pathologic examination of specimens, and the injection of tissue or purulent material into guinea pigs have followed a period when a correct diagnosis of tuberculosis was not made at all, or was deferred until massive gross infection of a

joint led to a sinus formation. Patients seen in the early years covered by this study usually presented late stages of the disease process, and the diagnosis was made by clinical examination, frequently confirmed by autopsy.

The diagnosis of tuberculosis in the year 1866 may well be questioned, for Koch<sup>17</sup> did not discover the tubercle bacillus until 1882. However, the first accurate clinical picture of a tuberculous lesion in a joint was drawn by Wiseman in 1676.<sup>18</sup> Clinical descriptions of tubercles appeared in the medical textbooks during the middle of the nineteenth century.<sup>19</sup> Review of actual case histories published in the early annual reports of the New York Orthopaedic Hospital indicates that the clinical picture of tuberculosis in bones and joints was well differentiated at that period.

Although there has been an actual decline in incidence of tuberculous lesions in bones and joints, this decline has been accentuated by improvement in the clinical diagnosis of these lesions, and recognition of other conditions previously unknown. It is now estimated that at least one-quarter, or perhaps even one-third, of the patients diagnosed as suffering from tuberculosis of the bones and joints in the early years of the Dispensary were really afflicted with other diseases simulating tuberculosis. Malignancy, mechanical causation for low back pain, and rupture of the nucleus pulposus of the intervertebral disc have become distinct clinical entities to those treating diseases of the spine. Acute arthritis, coxa plana and coxa vara, slipping of the upper femoral epiphysis and similar lesions at the hip joint are now recognized. Likewise, Charcot's disease, infectious arthritis, and hydrarthrosis are no longer subject to lump classification as "white swelling of the knee joint" and considered as due to tuberculosis.

Because of early diagnosis, the treatment of tuberculous lesions by arthrodesis has been instituted earlier in the disease process, greatly diminishing the period and cost of hospitalization and convalescence

for the patient, and enhancing the likelihood of cure of the lesion, as was so strikingly shown by Cleveland and Pyle.<sup>20</sup> No longer is the dressing room of the New York Orthopaedic Dispensary lined with patients awaiting attention because of prolonged, draining, tuberculous sinuses. Early and accurate diagnosis has been a marked factor in the control of bone and joint tuberculosis in the Dispensary.

The decrease in incidence of tuberculous lesions in bones and joints is portrayed in the accompanying tables. The figures used in the tables represent those listed in the annual published report of the Hospital. No attempt has been made to correct for errors of diagnosis which occurred in the earlier period covered by this study. During the early years of the Dispensary's existence there was a predominance of patients with tuberculous lesions, particularly of the spine, hip and knee. In the first, ten-year period up to January 1, 1877, a total of 2,110 patients had been seen. Of this number, 752 were afflicted with Pott's disease, 508 with tuberculosis of the hip, and 118 with tuberculosis of the knee. During a comparable ten-year period ending January 1, 1937, 102,066 new patients were examined at the Dispensary. Of these, 414 suffered from tuberculosis of the spine, 165 from tuberculosis of the hip, and 118 from tuberculosis of the knee. The percentage of all new patients with tuberculosis of the bones and joints in relation to total new patients applying for dispensary treatment has fallen from 65.3 per cent during the first ten years to 0.9 per cent during the past ten-year period. Percentage determination of tuberculous patients compared with total new patients seen in the Dispensary is necessary because this is the only method possible with comparable figures available in the records of the Hospital. Whitman has recently reported a similar decline in tuberculosis of bones and joints at the Hospital for the Ruptured and Crippled in New York City, where in 1910, 600 new cases of tuberculous disease were recorded at the Hospital and 35.3 per cent

of the patients treated in the wards were of this character.<sup>21</sup> In 1930 the number had been reduced to 80 and the proportion in the wards to 2.7 per cent. The percentage of orthopedic forms in relation to total tuberculosis cases admitted to the Children's Hospital in Boston, fell from 90 per cent in 1884 to 22 per cent in 1930.<sup>22</sup> The number of institutions in New York City with facilities for treatment of bone and joint tuberculosis has increased materially in the past seventy years, and it is probable that the records of these hospitals would show a similar decline in incidence of tuberculous disease.

Important to consider, when faced with the above figures, are the marked advances which have been made by orthopedic surgery during the past seventy years. Thousands of patients are being treated at the New York Orthopaedic Dispensary and Hospital for bursitis, low back pain, foot ailments and other conditions previously within the domain of the general practitioner. It is not intended to convey the impression that the incidence of bone and joint tuberculosis has diminished to such strikingly low percentages as the above figures would imply.

In New York City the population of children under ten years of age has remained about the same since 1910, when there were 945,343 in this age group. In 1920 there were 1,097,359 and in 1930 there were 1,112,884 children in the same age group. The population of the city for these years was as follows: 1910, 4,766,883; 1920, 5,620,048 and 1930, 6,930,446. Inasmuch as the incidence of tuberculosis is relatively higher in children, this factor has specific significance when considering the prevalence of tuberculosis in New York City. On the other hand, the great influx into the city of rural folk who bring with them no immunity toward tuberculosis, as pointed out by Jostes, may tend to increase the prevalence of tuberculosis in the cities.<sup>23</sup>

Hyde<sup>24</sup> has stated without numerical confirmation that hospitals and clinics in large centers show no diminution in the

TABLE II

SPECIFIC FORMS OF BONE AND JOINT TUBERCULOSIS AMONG ALL NEW DISPENSARY PATIENTS, 1867-1936

	1867 to 1876	1877 to 1886	1887 to 1896	1897 to 1906	1907 to 1916	1917 to 1921	1922 to 1926	1927 to 1931	1932 to 1936
Spine.....	752	922	879	901	855	469	354	282	132
Hip.....	508	1,163	842	769	807	433	252	97	68
Knee.....	118	370	255	306	269	217	162	91	43
Ankle.....		109	95	133	144	82	53	21	15
Wrist.....		16	17	24	18	21	31	17	10
Shoulder.....		19	35	33	20	20	20	15	5
Elbow.....		17	34	52	35	29	15	20	12
Sacro-iliac.....		1	0	0	56	18	26	10	7
Tarsal.....			19	40	41	11	14	11	6
Other.....						11	1	24	14
Total tuberculosis cases..	1,378	2,617	2,176	2,258	2,245	1,311	928	588	312
New patients.....	2,110	5,888	8,099	12,473	23,579	35,154	45,168	49,220	52,846
Percentage.....	65.3	44.4	26.9	18.1	9.5	3.7	2.1	1.2	0.6

number of cases under treatment, but rather increased numbers of patients with tuberculosis of bones and joints in spite of the tuberculin testing of cattle, pasteurization of milk, and the excellent living conditions of the past decade. However, there has been an actual decrease in tuberculosis of the bones and joints at the New York Orthopaedic Dispensary and Hospital, as shown in Table II. Interesting to note in this table is the relative constancy of the number of patients with tuberculosis of the upper extremity. Tuberculosis of the shoulder, elbow, wrist and hand is subject to fewer confusing clinical entities, the diagnosis being more definite. In the weight-bearing joints the incidence of lesions simulating tuberculosis is much more pronounced. The sudden statistical increase in tuberculosis of the sacro-iliac joint following 1907, as shown in Table II, may well be ascribed to the improvement in x-ray technique which has taken place.

Thus it is seen that the control of tuberculosis is shared by a majority of the physicians of the country, whose efforts already have produced such highly commendable results. With improved standards of living and improved hygiene, further de-

cline in the incidence of bone and joint tuberculosis is to be anticipated. The purpose of this paper is to present the figures available in the New York Orthopaedic Dispensary and Hospital regarding the incidence of tuberculosis of bones and joints, in the hope that other hospitals will be stimulated to make similar reports. It is realized that data from one institution alone must be considered unreliable in connection with the general incidence of bone and joint tuberculosis, due to the multiplicity of factors influencing the picture in such a large center as New York City.

## SUMMARY

An actual decrease in the number of patients suffering from tuberculosis of the bones and joints has been observed at the New York Orthopaedic Dispensary and Hospital. The percentage of patients with tuberculosis of bones and joints, as compared with total new patients applying for dispensary care, has fallen from 65.3 per cent to 0.6 per cent during the past seventy years. Similarly the incidence of bone and joint tuberculosis in children, in relation to all new dispensary patients, has fallen

during the past twenty-five years from 9.7 per cent to 0.1 per cent. It is emphasized that these figures are unreliable in estimating the general incidence of tuberculosis of bones and joints throughout the country, and it is hoped that other hospitals will make comparable reports. A discussion of factors entering into the decline of tuberculosis of bones and joints has been presented.

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# PERONEAL NERVE LESIONS IN ORTHOPEDIC CONDITIONS

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**P**ERONEAL nerve lesions represent a frequent complication in the treatment of injuries and diseases of the lower extremities. The peroneal nerve, together with the musculospiral nerve, is the most vulnerable nerve of the human body. Its superficial situation behind the head of the fibula exposes it very easily to pressure from without, and if too much tension is applied on the nerve during a forceful corrective maneuver of a flexion deformity of the knee joint, it will become most marked over the head of the fibula where the nerve is rather firmly fixed to the bone.

It is, therefore, absolutely necessary to check up on the peroneal nerve immediately after every manipulation or surgical intervention on the lower extremity. This is best done by having the patient wiggle his toes. Wiggling of toes consists in active dorsal and plantar flexion whereby the dorsal flexion is the important part for the control of peroneal nerve action. In cases of peroneal nerve lesion the patient moves only the flexors of the toes and as soon as this motion relaxes the toes go back to midposition. This, on superficial examination, may suggest active dorsal flexion. To rule out a peroneal nerve lesion with certainty the toes have to be dorsal flexed beyond the midposition. This should be done as soon as the patient awakens, preferably when he is still in the operating room.

If there are signs of nerve paralysis the causes should be detected in the operating room and relieved. Ischemia of the nerve is mainly responsible for these early lesions, either by pressure or by tension. The nerve quickly recovers if relieved soon from pressure or tension. The ischemia will lead to fibrosis of the nerve and interruption of conduction if it lasts longer.

Quite often one notices inability in dorsal flexion of the toes, while the peroneal nerve may be still intact. These apparent nerve lesions may be due to swelling, hemorrhage and pain after a surgical intervention, or to relaxation of the extensor muscles after, for example, a corrective wedged-shaped osteotomy. Following an operation on the foot through a lateral Kocher incision, after the dorsal muscles and tendons have been lifted from the bones, dorsal flexion of the toes is usually impaired for a few days by swelling and pain, more so for the lateral toes than for the big one. In cases of relaxed musculature it is quite a long period of time before the normal tone of the musculature is restored and active dorsal flexion is again possible.

Of greater importance, of course, are the true peroneal nerve lesions which very often after a short duration may become irreparable. Their early recognition is imperative, but even with this, it is by no means always certain that the nerve will recover. During the last few months we have had occasion to observe three cases of peroneal nerve lesions which are of more than usual interest.

A 28-year old man was admitted to the hospital with a typical history of gonorrheal arthritis of the left hip joint. The roentgenogram showed a destructive lesion of the left hip with erosion of the joint surfaces and narrowing of the joint space. There was extreme tenderness of the hip region and the patient resisted every attempt at motion. He could not sleep at night and had lost about 20 pounds in weight. Because of the painfulness and the beginning flexion deformity of the hip joint, it was deemed advisable to manipulate the extremity into correct position and to apply a hip spica cast for immobilization until the acute symptom subsided. The hip deformity was easily corrected and the double hip spica cast was applied under gas anesthesia,

## Freund—Peroneal Lesions

well padded, extending to the toes on the left and to the knee on the right. The patient felt much better immediately after the cast was applied. Two days later he was discharged home for five weeks. When he returned to the hospital his general condition had remarkably improved and he had gained so much weight that the cast had become too tight. While he was at home a complete peroneal nerve palsy had developed on the left side and an incomplete one on the right where the cast had extended only to the knee joint, i.e., above the head of the fibula. On this side the extensor longus of the big toe was completely paralyzed and there was weakness of the extensors of the toes. The peroneal muscles were functioning quite well. The test with the galvanic and faradic currents revealed a complete reaction of degeneration.

It is quite clear that in this case the peroneal nerve lesion must have developed very slowly. As the patient was gaining in weight, the plaster cast became gradually filled and there must have been pressure over a very extensive area. Nevertheless, it is most probable that complete peroneal nerve lesion on the left was due to direct pressure upon the nerve behind the head of the fibula, although there was no pressure sore on the skin. The incomplete paralysis of the peroneal nerve on the right, however, was not caused by localized pressure. Here the peroneal nerve came to harm in the popliteal fossa where it became slowly more and more compressed. The patient mentioned afterwards that during his stay at home for some days he had felt tightness and pain at the lower edge of the cast on the right side.

This case shows how important it is to check on toe motion during the entire period of immobilization. This should be done in the hospital routinely, by the medical attendant when making rounds or by the nursing staff. Every patient with a plaster cast on the lower extremity should be urged to wiggle his toes. When this patient left the hospital he did not show any signs of peroneal nerve palsy. No one thought to advise him or his relatives to watch his toe function, because it is unusual

for a peroneal nerve lesion to develop so many days after the cast has been applied. However, late injuries to the peroneal nerve are very clearly possible, especially in patients who, due to an acute disease, have lost a great deal of weight before the cast is applied.

The complete reaction of degeneration of the left side in this instance gives a very good prognosis. A brace was applied to the left leg to check the drop-foot and, by a T-strap, an attempt was made to prevent varus deformity. The right foot was left free. Here the patient had sufficient dorsal flexion to give him a fairly normal take-off of the foot. If there should be no return of peroneal nerve function on the left, it is intended to stabilize the foot by fusing the subastragalar joints and to prevent the dropping of the foot by a posterior bone block.

We mention here another case of peroneal nerve lesion which fortunately cleared up after more than two months:

Tuberculosis of the knee joint was observed in a man of about 40 years of age at the Florida Medical Center. The knee joint had a flexion deformity of about 20 degrees and valgus of 15 degrees. There was quite firm ankylosis clinically but no signs of a bony ankylosis in the roentgenograms. The lesion dated from childhood and showed a tendency to occasional flare-ups. An arthrodesis of the knee joint was performed with economic resection of the crooked joint surfaces followed by realigning of the extremity and immobilization with the aid of two bone pegs which were driven diagonally from the condyles of the tibia into the opposite condyles of the femur. The operation was performed without any complication. A long leg cast was applied, and as soon as the patient awakened a complete peroneal nerve palsy was noticed. A window was cut over the head of the fibula, but there were no signs of pressure by excessive tightness of the cast.

The patient was discharged home with little hope that he would recover from his palsy. He returned six weeks following the operation, still showing complete peroneal nerve palsy. However, the burning sensation in the dorsum of the foot which had been most annoying for the first two weeks after the operation had

subsided. The knee joint was not quite solid and a new cast was therefore applied.

The man returned again after two more weeks and at this time beginning return of peroneal nerve function was noticed. The cast was removed and a roentgenogram taken. The picture revealed that the bone peg which had been driven from the inner condyle of the tibia into the outer condyle of the femur had missed its way slightly and had gone with its point into the popliteal fossa and extended into the soft tissues for about 1 inch. This explained all the symptoms. The peroneal nerve had been hit and displaced by the bone graft. Pressure from within had caused a complete peroneal nerve palsy with motor and sensory symptoms. Later on, the bone graft, as far as it extended into the soft tissues, underwent absorption, which released pressure and tension on the peroneal nerve. First sensation and then motor function completely returned.

Brief mention may also be made of another case in which a most marked knee deformity following infectious polyarthritis was corrected by a resection of the condyles of the femur and arthrodesis.

A 27 year old man who during seven years had contracted most severe joint deformities. Both knee joints were bent at acute angles with complete posterior dislocation of the tibia. The correction of the deformity was obtained by resection of the condyles of the femur, lengthening of all the hamstring muscles and posterior capsular plastic. The peroneal nerve during the procedure was brought into safety and great care was taken not to bring it under too much tension while straightening out the leg. The patient showed free dorsal flexion as soon as he awakened.

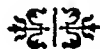
Three days after the operation, however, he began to complain most severely about a

burning sensation on the plantar side of the foot. There remained good dorsal flexion of the toes. The distressing burning of the foot could not be relieved by splitting the cast over the ankle. It lasted for about four days, then it subsided and cleared up perfectly. This symptom was certainly not due to tension of the nerve. If the peroneal nerve comes under tension it seems that its motor fibers are more quickly affected than its sensory fibers. A burning sensation along the tibial nerve must have been due to a traumatic neuritis, edema and hemorrhage which followed the operation. The operation was performed under tourniquet. It was quite extensive and must have led to considerable postoperative hemorrhage and swelling in the popliteal fossa. It took about two days to develop sufficient edema to affect the nerve.

In such cases all attempts to trim the cast with the idea of removing pressure are futile and often even contraindicated because they endanger the obtained correction of the extremity. One must wait until the swelling subsides and give analgesics to the patient in the meanwhile. The nerve lesion usually clears up.

#### SUMMARY

Peroneal nerve lesions are a frequent complication in orthopedic treatment of lesions and injuries of the lower extremities. They can be reduced very considerably by a careful check-up of the toe motion immediately after the treatment. Most of the lesions are due to pressure or tension on the nerve, leading to anemia and later on to interruption of conductability. The quicker pressure and tension are released, the better the chances for restoration of function.



# COCCYGODYNIA\*

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AN Englishman by the name of Simpson<sup>1</sup> in 1859, gave an excellent clinical description of pain in the lowermost portion, tip, or tailbone of the spine. He dignified the condition by the now popular term "coccygodynia." He reviewed reports of injuries in the coccyx dating back to the sixteenth century, and then, suggested tenotomy of the ligamentous structures as proper therapy for the pain. The first recorded coccygectomy was done in 1726 by a Frenchman, Petit, for what was probably tuberculosis. Nott, an American, reported a case in 1844 and suggested surgical removal, which procedure was again stressed by Scanzoni in 1861. This was followed by a wave of enthusiasm for this operation when Beach, in 1899, characterized it as "notably unsuccessful." This was followed by a wave of conservative treatment which later was discarded as not wholly satisfactory. Later alcohol injections were advised. Suermondt wrote in 1931 that epidural injections of procaine relieved some of his patients. In 1932, Kleckner<sup>2</sup> injected a 5 per cent solution of quinine and urea hydrochloride subcutaneously about the coccyx at intervals of one or two weeks. He reported relief for patients so treated. Another method which has been quite satisfactory in our hands for the treatment of pruritus may also be suggested for painful coccyx, namely, the subcutaneous injection of 5 c.c. of Gabriel's solution of nupercaine (Ciba).

Hobart<sup>3</sup> reports marked success with the manipulative treatment of coccygodynia. He prepares his patients "psychologically" and then anesthetizes them with nitrous oxide. With the patient on his abdomen the operator manipulates the coccyx between

the index finger inside the rectum, and the thumb over the coccyx externally. This procedure loosens the adhesions and relieves congestion about the nerve plexus. Mock agrees with this procedure and believes all patients should receive the benefits of manipulation before surgery. More manual manipulative measures might mean making much misery milder, as certain cultists would have it.

## ANATOMY

Certain anatomic structures must be appreciated to have an understanding of the symptoms. The coccyx derives its name from a Greek word meaning cuckoo, based on the resemblance of the coccyx to a cuckoo beak. Colloquially it is called a tail or crupper bone. The four coccygeal segments are united in the adult to form the coccyx. In general, the coccyx is a triangular osseous formation, the whole bone being curved in a forward direction; it is concave in front and continues the curve of the sacrum.

Caldwell and Moloy<sup>4</sup> made a study of anatomic variations in the male and female coccyx and showed that the greater sciatic notch in the female was 13 mm. wider than in the male. There is less tendency in the female to have the inclination of the sacrum and coccyx forward into the pelvic cavity. Therefore the male coccyx is more protected, being tucked in between the ischia and possibly explains the greater incidence of trauma to the female coccyx.

The nerve supply of the region is rich.<sup>5</sup> Spinal nerves supply numerous ramifications through the coccygeal plexus. Involvement of the sympathetic system

\* Presented before the Seattle Surgical Society, December 18, 1937.

through the ganglion impar offers opportunity for a variety of symptoms, called coccygodynia.

region that pure coccygodynia may be considered a rarity. Rectal examination will reveal the position, mobility, and

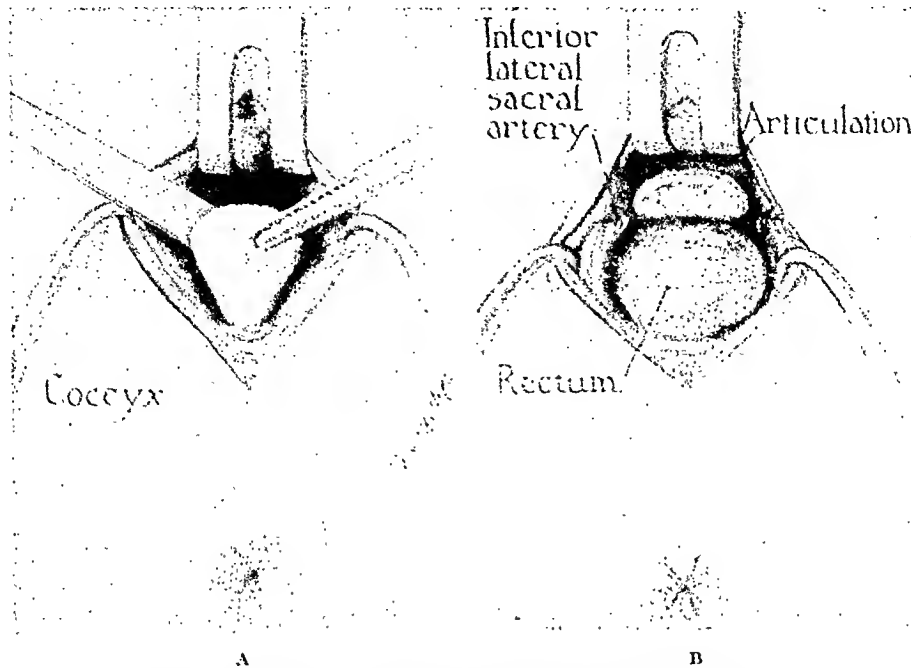


FIG. 1. Excision of coccyx. A, midline incision with levering out of coccyx. B, underlying rectum and sacral articulation

The surgical anatomy<sup>6</sup> of importance in this region consists of the following: the gluteus maximus attached to the posterior surface of the coccyx, the coccygeus to the anterior surface, the sphincter ani from its tip in front, and the levator ani from its tip behind, the sacrococcygeal ligaments to its upper aspect.

Different types of coccygodynia may exist, but in our opinion there is only one true type, that is, painful coccyx, whether caused by a tumor, trauma, or infection. Psychogenic or remote organic causes for pain in this region should not be classified under this heading, and cannot be expected to respond to conservative or radical treatment of the coccyx. Neither should conservative or radical measures be condemned for failure when applied in such cases.

#### DIAGNOSIS

The diagnosis of coccygodynia can only follow a careful history, physical examination, and roentgenography. There are so many other painful combinations in this

tenderness of the coccyx. Passive motion should reproduce the pain in the complaint.

Pain may be present during defecation or urination. The character of the pain is variable. It is not uncommon to see a patient sit with one side elevated to remove pressure from the coccyx.

In differential diagnosis a pilonidal cyst is the most common lesion from which a painful coccyx is to be distinguished. There is usually a dimpling of the skin in a cyst, with a discharging sinus. Usually no pain is elicited on rectal examination because a pilonidal cyst is dorsal to the sacrum. Non-traumatic arthritis is to be excluded. A tumor of the cauda equina may cause referred pain to the coccyx, with sensory anesthesia and paralysis which may be flaccid or spastic. Childbirth trauma plays a minor rôle in the experience of most writers.

#### PROGNOSIS

Duncan<sup>1</sup> reported 278 patients with the complaint of a painful coccyx admitted to

the New York Orthopedic Dispensary during a ten year period. Ninety-seven per cent were females, and 89 per cent recalled

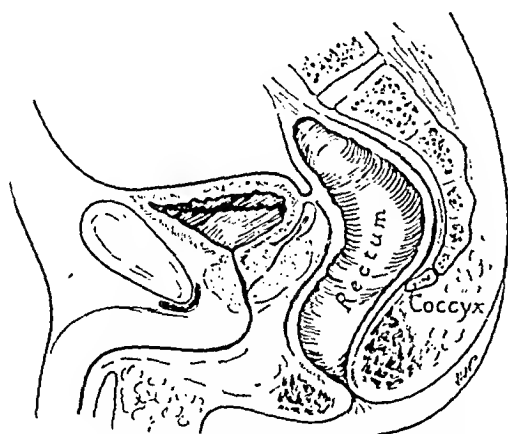


FIG. 2. Diagram of sagittal section, illustrating proximity of coccyx to rectum.

an injury to the coccyx. Under conservative management all but 3 per cent of the fifty-four patients followed up were re-

cases of traumatic arthritis. Coccygectomy, in Hamsa's experience decreases the length of time required to establish a favorable end result and thereby establishes itself as an economic factor in treating coccygodynia.

#### EXCISION OF COCCYX

The patient is placed on the abdomen with the foot of the table lowered. We prefer a low spinal anesthetic. The area is prepared with ether, alcohol, and tincture of iodine, or tincture of merthiolate may be used if desired. The sacrococcygeal articulation is determined along with the tip of the coccyx. Rarely is it necessary to insert the finger into the rectum.<sup>8</sup> The incision is made in the midline just above the sacrococcygeal articulation and passes vertically downward, ending just below the tip of the coccyx. (Fig. 1.) The transverse incision has been suggested because it is more removed from the anal opening and is less

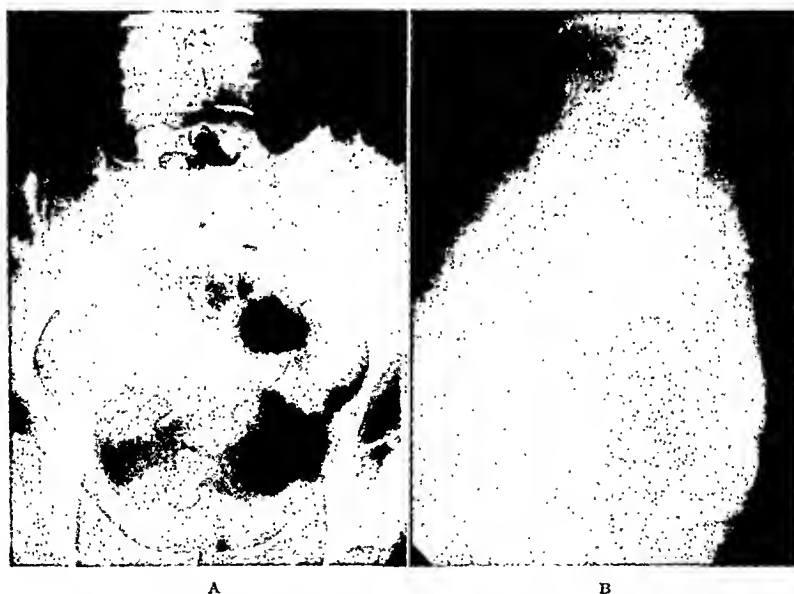


FIG. 3. A, lateral deviation of coccyx. B, anterior dislocation of coccyx.

lieved within six months. Thirty patients, or 11 per cent, had operative resection with relief complete in 74 per cent, partial in 9 per cent, and no relief in 17 per cent.

Hamsa<sup>7</sup> of Iowa reports 84 per cent good and fair results from surgical removal as compared with 62 per cent good and fair results in expectant therapy while treating

likely to become infected, secondarily. The elliptical incision appears to have no rational basis for use here and would appear to delay healing and result in a painful scar. The skin and fascia are incised through to the bone. The bone is usually more easily removed by freeing its posterior surface and lateral borders, then

disarticulating and levering out its upper end. While the coccyx is being drawn backward, its anterior surface is freed from above downward, dissection being continued against the anterior surface of the bone so as to avoid injuring the rectum. (Fig. 2.) The tip of the sacrum is curetted or smoothed off with a rongeur. The lateral sacral arteries may be ligated separately, thus controlling practically all bleeding. The incised muscles are sutured together deeply with interrupted chromic catgut, and the superficial wound closed with dermal. A collodion dressing may be applied. The patient may leave the hospital in a few days.

#### CASE REPORTS

Mr. P. (Fig. 3A.) This patient was a man of 65 years, who had a constant pain in his rectum for many years. He had a hemorrhoidectomy with no relief. Rectal examination revealed much pain on motion of the coccyx. X-ray showed lateral deviation of the bone. Excision of the coccyx gave complete relief from local pain but the patient still complained of a discomfort in this region, mainly because of a long standing cancer phobia.

Mrs. A. (Fig. 3B.) This patient is a female aged 32 years, who had fallen in a sitting position and slid down several steps twenty months before examination. She was pregnant at the time. The baby was born prematurely but lived. The patient had severe pain since that time in spite of strapping and other forms of the masterful inactivity type of treatment. She had so much pain that she could not sit through a complete single feature movie, even with a cushion. The coccyx was anteriorly dislocated and freely movable, but was quite

painful, particularly at defecation. Removal of the coccyx gave complete relief.

#### CONCLUSIONS

1. Painful coccyx is usually the result of injury.
2. Coccygodynia is more common in women because the anatomic posterior prominence of the coccyx in the female pelvis exposes it to the greatest etiologic factor, trauma.
3. The treatment may be conservative for at least three months. This may consist in local support, subcutaneous injections, or manipulations.
4. The operative treatment herewith described and illustrated gives about 85 per cent good results and may be employed early for economic reasons.

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# THE REPAIR OF CRANIAL DEFECTS WITH CELLULOID

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CRANIAL defects were very common during the War following gunshot injuries of the skull, and neurosurgeons gained considerable experience in their repair. Autogenous bone grafts seemed the most hopeful method at that time and were generally used. During the post-War period I had occasion to examine some forty-two patients in whom cranial defects had been repaired with autogenous bone grafts by various neurosurgeons in the service, including myself. Thirty-four of these showed a complete or partial absorption of the graft, and in most of these evidence of absorption was observed within one year. Obviously, we may not consider autogenous grafts as entirely satisfactory for the repair of cranial defects.

In civil life cranial defects frequently follow compound craniocerebral trauma, and occasionally surgical sacrifice of areas of the skull becomes necessary because of various pathologic conditions. The osteogenetic function of the pericranium ceases, to a large extent, with the ossification of the cranial bones and the closure of the fontanelles. On rare occasions we observe evidence of osteogenetic activity in cranial defects, and then, usually only in the very young. Sufficient spontaneous bone regeneration in the skull is not to be expected for the repair of a defect larger than 1 cm. in the adult, and then the filling is imperfect. Because of the difficulty of repairing cranial defects with bone or cartilage grafts, neurosurgeons are often reluctant to sacrifice even relatively small fragments of the skull, though their surgical judgment may suggest a more extensive bone removal, particularly in osteomyelitis, tumors of the skull, or erosions from underlying meningiomas.

Cranial defects, unless large, are of themselves of little significance in the production of symptoms. The patient, however, often shows considerable anxiety regarding the "soft spot" in his head which he feels may not give proper protection to the brain. Pulsating cranial defects, however, are often attended by an instability syndrome in which dizziness and motor uncertainty are caused by straining, coughing, stooping, or strenuous exercise. This sensation of instability is often sufficiently intense to prevent the patient from attempting sudden movements or physical exertion of any kind because of a sensation of giddiness and a fear of falling.

Cranial defects may be particularly conspicuous when they are located beyond the hairline, as in the forehead or in a bald-headed individual, and when so situated should be considered from a cosmetic standpoint.

My first experience in the use of celluloid for the repair of a cranial defect was in 1913. A young man of 19 had been kicked in the head by a horse and sustained a compound fracture of the skull. There was no evidence of intracranial injury, but osteomyelitis, with two discharging sinuses, had developed when I first saw the patient. At operation I removed several sequestra and curetted the granulations. The dura was exposed over an area corresponding in size to a silver dollar. After about five weeks, suppuration had subsided and the scalp was completely healed.

The defect was located in the left frontal region, only partially covered by the hair. It produced a conspicuous deformity in that situation which greatly disturbed the young man and his family, and they requested that something be done to

correct the deformity. After waiting for approximately six months to avoid a possible recrudescence of infection, I re-

lowing this aspiration, healing progressed favorably and a good cosmetic result was obtained. Fourteen years later I

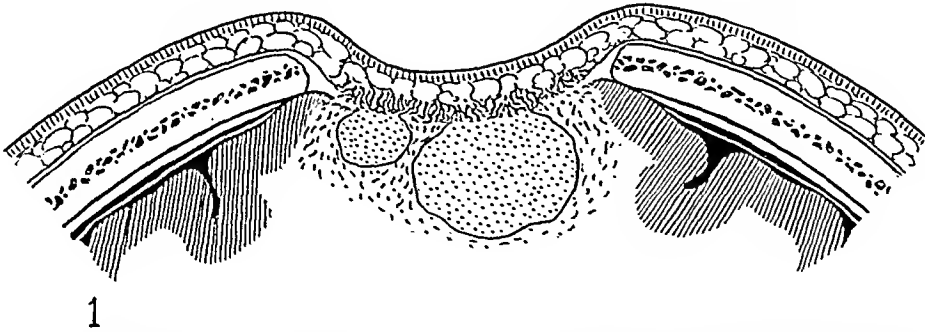


FIG. 1. Diagram of cranial defect with retraction due to cortical adhesion and cystic formation, showing the type of traumatic brain lesion commonly associated with cranial defects complicated by epilepsy.

paired the defect by using a bone graft from the flat surface of the tibia, inverting the periosteum. With this graft I was able to fill the defect satisfactorily, and there was no suppuration. About six months later, however, the defect appeared to be sinking, and pulsation was soon observed during coughing or straining. The bone graft had been absorbed.

In the meantime I had seen a reference in a German publication to the successful repair of a cranial defect with celluloid. I again operated on this man and inserted into the defect a piece of celluloid cut from a heavy soap box and sterilized overnight in alcohol. I found that by dipping the celluloid in very hot water I could bend it into the desired curvature. The defect was prepared by chiseling the outer table of the skull so that the celluloid could be inserted as an inlay. Several small holes had previously been drilled in the plate to permit the escape of any serum which might collect beneath it. The plate was fixed in place with catgut sutures passed through drill holes and the edges of the pericranium. The scalp was sutured with silk. After a few days there was some boggiess of the scalp flap and infection was feared, although the temperature was normal and there were no signs of local inflammation. An aspirating needle was passed through the center of the flap, and several c.c. of clear yellow fluid were withdrawn. Fol-

again saw this patient and the cranial defect had remained firmly filled. The scar was almost imperceptible.

During and after the War I did a number of secondary repairs with celluloid of cranial defects in which a primary autogenous graft had become absorbed. This use of celluloid in the repair of cranial defects has proved to be uniformly successful, as it is well tolerated by the tissues and does not undergo absorption. I have now used celluloid in the repair of more than 300 cranial defects. In this series there have been but five infections which necessitated the removal of the plate. In four of these, after allowing six months or more for the subsidence of the infection, the defect was again filled with celluloid which was perfectly tolerated. It is interesting to note that four of these five infections occurred in young girls within six months after plate insertion and seemed to be autogenous in origin. The other case was the result of an accident in which a carelessly treated scalp wound over the plate became infected.

These experiences in the repair of cranial defects have convinced me that celluloid, unlike almost any other foreign body used for implants in surgery, is perfectly tolerated by the tissues. For the repair of cranial defects it can be shaped by heat to conform to the curvature of the skull. The tissues grow through the holes in the plate and firmly anchor it. Its chief

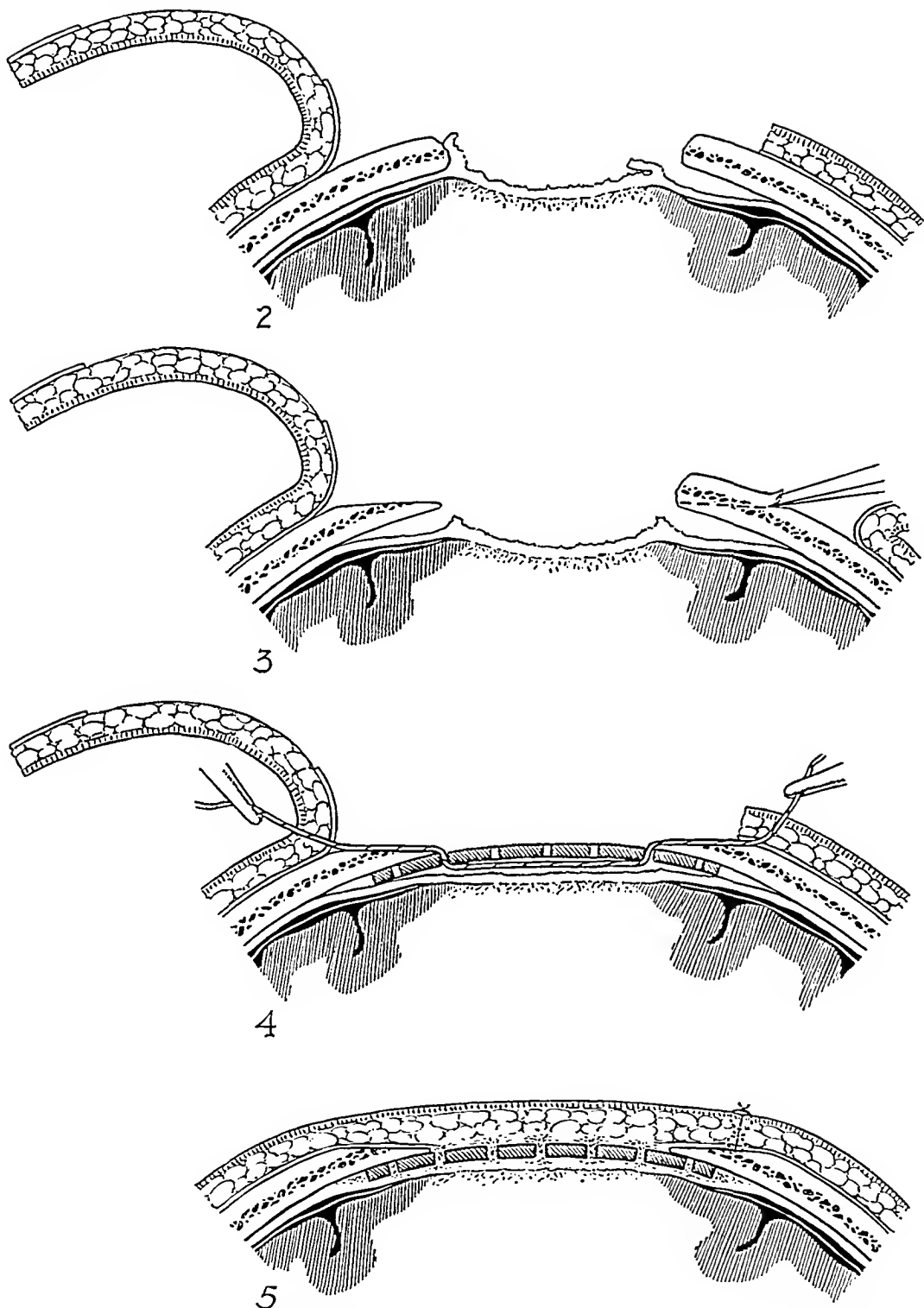


FIG. 2. Scalp reflected. Pericranium and dura detached from edges of defect.

FIG. 3. Chiseling edges of defect to improve contour. The chiseling is more safely done after plate is inserted.

FIG. 4. Plate inserted under bone. Suture passed through holes of the plate, showing method of temporary fixation.

FIG. 5. Plate in place with tissues grown through holes.

advantage over bone grafts is that it is not absorbed. Celluloid has the property of reacting to body warmth by slowly some underlying pathologic condition which had not been corrected at the original operation or which had recurred.

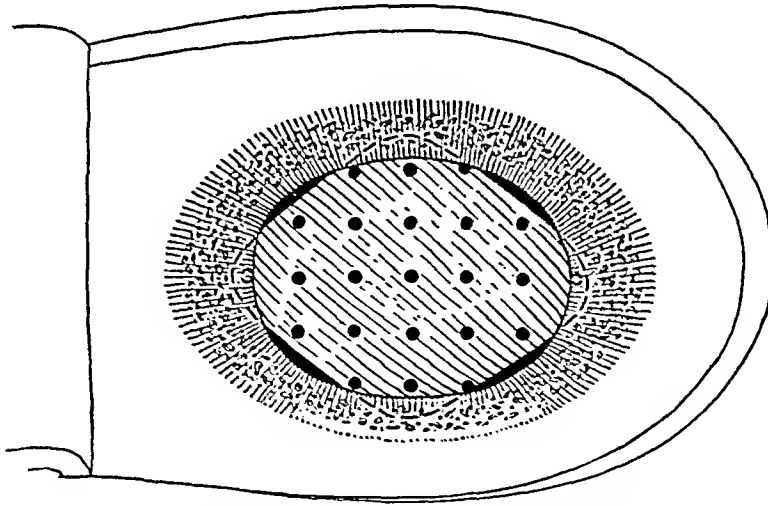


FIG. 6. Shape of flanges of plate as they pass under the bone. The bone is bevelled to meet the plate.

adjusting its shape to conform to local tissue tension, and thus pressure necrosis is avoided.

I have exposed the vertex of the brain some 260 times for the freeing of abnormal corticodural attachments in epilepsy, and for the care of other pathologic conditions necessitating this type of approach. An exposure of this area presents certain difficulties due to the tearing of emissary veins along the sagittal sinus and pacchionian granulations which have eroded the dura through the lacuna lateralis. These structures bleed very freely, and the bleeding is not readily controlled by ligature or suture. After such an exposure, the replacement of the bone flap is often followed by serious results due to hemorrhage under the flap. I found that by eliminating the bone flap and using a large celluloid plate to fill the defect such an approach could be satisfactorily accomplished. The slight pressure of the plate when in place is sufficient to control the venous oozing, and the perforations in the plate allow the escape of blood and serum which then accumulates under the scalp where it may be removed by aspiration.

On several occasions it has been necessary to remove such a plate to deal with

The plate was found to be well imbedded in the skull. The tissues had grown through the holes in the plate and had formed living sutures, holding it firmly to scalp and dura. The tissues in contact with the plate were as smooth and glistening as a normal peritoneum. The plate itself, through the warmth of the tissues, had gradually conformed in shape to the general contour of the skull.

#### TECHNICAL CONSIDERATIONS

In using celluloid plates for the repair of cranial defects, I have found a product of the Du Pont Viscoloid Company, known as pyralin, very satisfactory. This comes in sheets of various thicknesses, of which 0.06 inch, and the heavier 0.075 inch, seem well adapted to cranial repair and are sufficiently strong to give ample protection in large defects. These plates are transparent and perfectly smooth. The sheets of pyralin are cut for convenience in handling to 5 × 7 inches. Drill holes are made through the plate about 1 cm. apart. These holes are approximately  $\frac{1}{32}$  of an inch in diameter. Sterilization is effected by wrapping the plates in gauze and submerging them in a 50 per cent solution of ethyl alcohol for four hours. Denatured alcohol should not be used, as certain agents used

in the denaturing tend to soften or blister the plates.

At operation, when the scalp has been

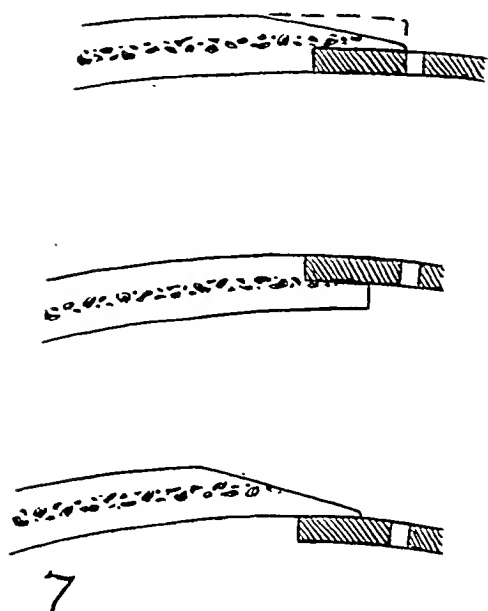


FIG. 7. Three methods of inserting celluloid plate in the repair of cranial defects: inner table inlay; outer table inlay; and plate below bone, as ordinarily used.

reflected, the edges of the cranial defect exposed, and the dura carefully separated from the bone, the defect is measured and a square or diamond-shaped plate is cut with heavy shears (such as are used for cutting tin) to its approximate size. The corners of the plate are rounded and left as short flanges to pass under the bone. If desired, the inner table of the skull may be cut away at suitable points to receive these flanges as inlays. Anchoring of the plate is seldom necessary as the pressure of the intracranial contents is usually sufficient to hold the plate in place. The edges of the skull defect are then bevelled with chisel and hammer to meet the level of the plate. This bevelling process should extend 2 cm. or more lateral to the defect edges to obtain better surface contour. Obviously, a rigid aseptic technique must be maintained throughout the procedure. It is important, in planning the flap incision, to

make certain that the subsequent suture line will in no place cross the plate, but lie several centimeters beyond the edges of the defect. A wide exposure also facilitates the bevelling of the skull to obtain a ridgeless contour at the edges of the defect. The scalp is carefully approximated with a double layer of fine silk sutures, the first layer in the glia, the second in the scalp, as is customary in cranial surgery. Great care should be exercised in cutting the ends of the buried glial sutures close to the knot. On each side of the flap, a drain is inserted—a very narrow strip of rubber tissue in small defects, split Dakin tubes in large defects—to serve as an escape for blood and serum. Drainage material is removed after forty-eight hours. The dressings are removed daily and replaced by fresh gauze saturated with alcohol. The superficial sutures are removed on the eighth day.

There is often observed a puffiness under the scalp due to a collection of blood and serum. Aspiration is usually done the day after the sutures have been removed. The center of the flap is shaved, carefully cleansed with alcohol or iodine, and, under strictly aseptic conditions, a needle is passed through the scalp and the fluid aspirated. Occasionally, several aspirations are required before the scalp contracts over the plate. Usually by the end of six weeks, the plate is fixed in place and the tissues have grown through the holes so that it is firmly anchored.

In the past year, two infections were observed and pus was found in the aspirated serum. Through the aspirating needle, a few c.c. of ether was injected and then allowed to escape after a retention period of a few minutes. In both instances, the infection was controlled by the ether injection. The results obtained in these two cases suggest that the injection of ether may prove to be a valuable means of controlling those early infections which occasionally occur. This treatment with ether was suggested and used by my associate, Dr. J. James Ganders.

The presence of an infection in the bone or surrounding tissues should serve as a contraindication to the insertion of a foreign body until that infection has been completely healed for at least six months.

Traumatic cranial defects commonly have some underlying cerebral pathologic condition—traumatic cysts, adhesions, etc.—and an associated epilepsy is not uncommon, occurring sooner or later, in my experience, in more than 60 per cent of cases. (It may be that I see an unusually large number of cranial defects associated with epilepsy as these patients are more often referred because of the epilepsy, than for the repair of a cranial defect.) I wish to emphasize that the repair of a skull defect, in itself, cannot be expected to influence greatly an associated epilepsy. A traumatic cranial defect complicated with epilepsy indicates very definitely an underlying cerebral lesion which should be corrected at the time of the cranioplasty. The prevailing view, or at least one which is so commonly expressed, that little can be done for an associated epilepsy is certainly not justified, as surgery can deal very successfully with those factors of cerebral traumatic path-

ology which are responsible for the manifestation of convulsive phenomena.

#### SUMMARY

1. The repair of cranial defects by various bone grafting procedures is usually unsatisfactory because of graft absorption.
2. Cranial defects, particularly when the dura has been involved, tend to pulsate and there develops an instability syndrome which can only be corrected by a repair of the defect.
3. Many large cranial defects have been filled with celluloid, which is perfectly tolerated by the tissues, is not absorbed, becomes firmly implanted in the skull, and can be readily shaped.
4. In more than 300 cases, there have been five infections necessitating removal of the plate. In four of these, subsequent repair of the defect was satisfactorily effected with celluloid, the plate being perfectly tolerated.
5. The simple repair of a cranial defect will not serve to correct an associated traumatic epilepsy. This requires correction of an underlying pathologic condition, which usually consists of corticodural fixations and cystic collections of fluid.



# PAINLESS RENDERING CLOSURE OF SUPERFICIAL WOUNDS\*

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THE method of closing superficial wounds and lacerations here presented has been found extremely practical and fundamentally sound. No claim is made for priority of discovery. I do not doubt that its very simplicity has commended itself to many practitioners in the past, but a reiteration of its details and indications will do no harm. An examination of some of the recent textbooks and a search of the American and English literature of the past five years has failed to reveal any such method, nor one as simple or as devoid of pain.

The method is an outgrowth of the time honored procedure of closing small superficial wounds with butterfly strips of adhesive. The latter is, however, not very applicable where one desires perfect approximation, for the broad base needed for the adhesive to adhere to the skin prevents the use of many strips placed close together as would be required for good skin approximation. Further, bridging a wound with a comparatively broad piece of adhesive causes irritation of the skin edges which does not lend itself to the formation of hairline or almost invisible scars.

During the past two years I have followed this plan in about thirty cases. The resultant scars in all but one case have been practically invisible. After a few months, during which time the initial erythema subsided, the scars were as satisfactory as those produced in plastic surgery. In the exception noted, the wound was grossly infected at the time of the accident, and drained for a considerable period, producing a thick scar.

## TECHNIQUE

When there is no coëxistent laceration of muscle or deep fascia, the skin surrounding

the wound is wiped dry. After this, a sizing is applied to aid the adhesive strips in getting a firmer grip on the skin. For this purpose, compound tincture of benzoin is painted on the skin and permitted to dry. Flaming the adhesive will allow it to adhere to the painted skin for at least ten days without irritation or appreciable loosening. Blood, serum, moisture and hot wet dressings have no effect on the adhesive qualities of modern waterproof tape.

Strips of adhesive are cut about one-half inch wide and long enough to project about three-fourth inch beyond the ends of the wound. If the wound is large and gaping, a wider piece of adhesive is used, for the tension placed on the sutures can be increased if there is a broader area of adhesive drawing on the skin. In some lacerations, as on the fingers, or on such prominences as the nose or ears, the strips may have to be narrower. Where too much tension will not be required, it has been found practicable to use quarter inch widths.

The adhesive strips are placed on the prepared skin, about one quarter of an inch away from the wound edges, and as parallel to them as possible. They are then sutured together with surgeon's silk or any household thread of suitable strength (size 8).

The suturing is begun outside the end of the laceration. A bite is taken on the edge of the adhesive on the side proximal to the wound. A continuous suture is run from one adhesive strip to the other as shown in Figure 1. As each bite is taken and drawn tight, the edge of the adhesive through which the suture was just passed is gently pressed down with the fingertip or thumb forceps. This prevents slipping and avoids the necessity of keeping the suture continually on tension. As the thread is drawn

\* From the Department of Surgery, Coney Island Hospital, Brooklyn, New York.



tight, the wound edges approximate by themselves. With practice, inversion of the edges is easily avoided.

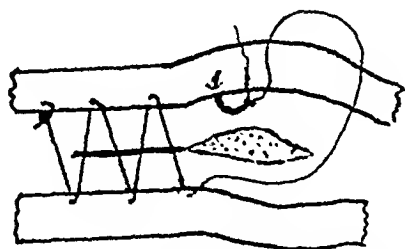


FIG. 1. Adhesive strips parallel to gaping wound. Suture in adhesive draws wound edges together.

It is best to leave no elevation of the adhesive near the wound for insertion of the needle and thread. Leaving one edge elevated forms a line of cleavage between skin and adhesive, so that the tape is usually lifted completely off before the suturing is completed. The needle is simply slipped between the skin and the superimposed adhesive without disturbing the bond between the two. A thin curved cutting edge needle usually penetrates adhesive without lifting it from the skin.

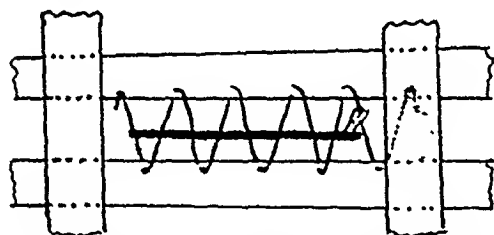


FIG. 2. Closure completed. Drain projects from end of wound. A vertical strip of adhesive placed at both ends to prevent suture line from being lifted. Strip on right used to fasten last suture without tying a knot.

In the case of irregular lacerations, where sharp angles or corners of tissue must be approximated, it is best to apply preliminary strips of adhesive as shown in Figure 3. A suture or two through these will fasten the angles of the laceration in proper position. After that, strips are applied as previously described and sutured in the usual manner. Where the angle of the wound is not too acute, one may place the strips as shown in Figure 4, parallel to the general direction of the wound

edges, without applying preliminary tension strips.

The method above described has been

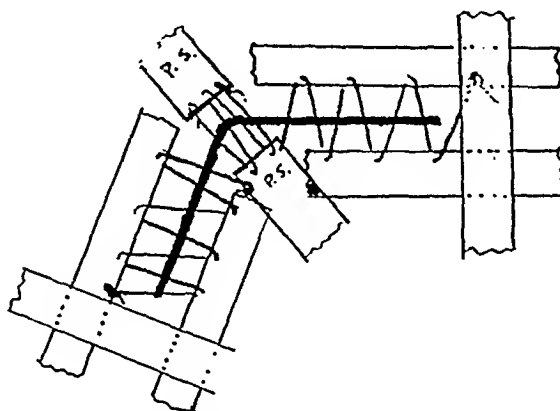


FIG. 3. Treatment of angulated wound. Preliminary strips (p.s.) and sutures are applied to fasten angle of wound before uniting the linear portion of the wound.

used in lacerations which extended in a spiral direction along a finger or around the palm of the hand, lacerations which passed over creases on the flexor surfaces. In these cases the adhesive strips were placed parallel to the wound edges, but they were made to hug the skin and invaginate at the creases. The first sutures taken in such

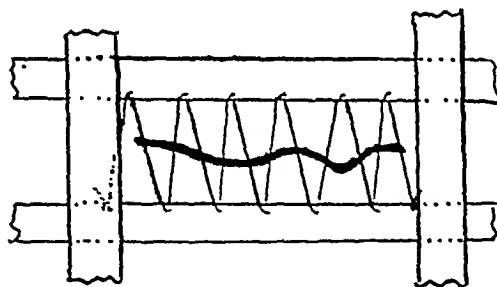


FIG. 4. Treatment of irregular wound. Adhesive placed parallel to general direction of wound.

situations are interrupted in order to approximate the crease marks. Then a continuous suture is run along the length of the wound.

Even where the wound is subject to motion and tension, as in the hand or fingers, no gaping need be feared. If the adhesive has been well applied it will hold the wound edges together firmly. If necessary, a splint may be applied to keep the injured part at rest, though this is rarely necessary except possibly in some finger wounds.

After the sutures are in place, it is sometimes advisable to place additional adhesive at right angles to the suture strips. (Fig. 2.)

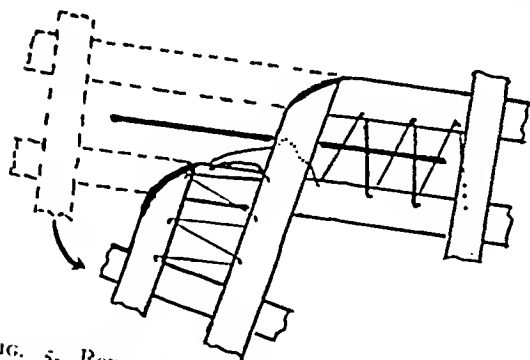


FIG. 5. Removal of sutures accomplished by lifting adhesive and sutures en masse from surface of healed wound.

ension sutures are not required for coaptation of skin edges, suture of parallel adhesive strips with a broad base will serve very well.

When deep fascia and muscle are lacerated, requiring separate sutures, the wound cavity is filled with 5 per cent novocaine solution and the fluid allowed to remain there for about three minutes. This will anesthetize the deeper tissues for the insertion of catgut, and will even anesthetize the skin for superficial débridement. Closure of the skin may then proceed in the manner described.

Removal of sutures after five to seven days is the simplest procedure. The adhesive is loosened at one end and is removed, sutures and all, at one sweep. (Fig. 5.) There is none of the pain due to tugging at the usual type of skin sutures.

With the method here described, the adhesive apparatus may remain in place the full seven days without producing any stitch scars. It is no longer necessary to run the risk of having a gaping in the wound when, in order to prevent ugly scars, sutures are removed from facial wounds in three days, as is the present practice. Should hot wet dressings be desired as an adjunct in therapy, they will not interfere with the proper coaptation of the wound edges. Waterproof adhesive will hold just as well, provided the skin is prepared as described.

#### COMMENT

This method is advocated for use in suitable wounds. Relieving the patient from unnecessary pain is adequate compensation for the extra precautions taken. Wound healing in cases not grossly infected at the time of injury is promoted by lessening the amount of additional trauma inflicted on a wound by penetrating sutures. Should infection ensue, there is no obstacle to self-drainage. Suture removal in the event of a clean or infected wound is rendered absolutely painless.

No mention has been made of antiseptics and débridement. It was my practice to apply the conventional antiseptics in and around the wound. At present, however, I merely wash it with a soap and water solution after picking out all gross contaminants and blood clots with a thumb forceps. I feel that a perfunctory dab at the depths of a wound with an applicator swab moistened in an antiseptic is in all probability a waste of time. I do not believe that a streptococcus or staphylococcus will succumb to a few seconds' immersion in the usual wound antiseptics. If antiseptics are applied for longer periods of time, they act as tissue irritants, and painful ones at that. Where the resistance of the tissues is lower than the virulence of the contaminating organisms, infection probably ensues anyway. Apparently there is no difference in outcome if only soap and water cleansing is employed.

Where débris is found in the wound and infection is feared, a rubber dam drain is placed in the depths of the wound and brought out at one end. (Fig. 2.) This is left in place for twenty-four hours. If débridement is necessary, this method of wound closure is still applicable, provided too much tissue is not removed. When deep

# THE TREATMENT OF VARICOSE VEINS IN PREGNANCY\*

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THE presence of varicose veins during pregnancy has not heretofore been recognized as a complication of much consequence, and up almost to the present time treatment for this annoying condition has been given little attention. The patient has been dismissed with the advice that she keep off her feet as much as possible or wear a bandage for the support of her legs.

Few physicians realize the often great discomfort and the disability resulting from varicose veins. The sense of weight and heaviness, the feeling of fatigue, especially at night, and the pain and cramps in the legs, are symptoms suffered by the patient but rarely elicited by the examining physician. Yet these complaints increase in severity as the period of pregnancy continues and as subsequent pregnancies recur.

A great deal of interest has been aroused, and considerable impetus given to the problem of varicose veins in general because of the success and almost universal acceptance of the method of treating these veins by the injection of sclerosing solutions. My own personal experience with over 10,000 injections has convinced me of the efficacy of this method and suggested the possibility that it be applied to pregnant women.

In October, 1931 we established at the Margaret Hague Maternity Hospital, a Varicose Vein Clinic, the first of its kind, we believe. Our study of over 1,000 pregnant women, with over 725 cases treated by injection, is the basis for this report.

*Occurrence.* Varicosities in pregnant women appear at any time during the period of pregnancy, and increase in size and number as the pregnancy continues. They may make their appearance with the

first or any other pregnancy, but once they do appear, are always evident again in subsequent pregnancies. In practically every case they either disappear or diminish in size after labor. In the majority of cases the veins disappear in this way after the first pregnancy, but with each successive gestation there is less tendency to spontaneous disappearance and eventually the varicosities become permanent.

In our series the majority of patients who presented themselves for treatment and observation, came during their second and third pregnancies. There were many patients in whom varicosities appeared for the first time during their fifth and sixth pregnancies. Our observations give the impression that every woman is a potential varicose vein case and if she has enough pregnancies she will eventually have varicose veins.

*Etiology.* The cause for the appearance of varicose veins during pregnancy has never been definitely established. The old, and for a long time commonly accepted theory, of pressure of a pregnant uterus on the pelvic vessels is not adequate. If the enlargement of veins were due merely to pressure and interference to the return flow of circulation, any attempt to compress the superficial circulation or interfere with the flow in these newly enlarged veins would be attended by added discomfort on the part of the patient. On the contrary, the obliteration of these veins produces comfort and relief and we have noticed no appearance of new dilated superficial veins after those already present have been treated.

The enlargement of the veins, we believe, is due to some disorder of the ovarian secretion. We see this same enlargement

\* From the Margaret Hague Maternity Hospital, Jersey City, New Jersey.

during menstruation and also during the menopause. Evidently some secretion is lacking at the menstrual period and during gestation which ordinarily tones up the venous walls; or some toxin may be elaborated which acts upon the veins; the factor of gravidity contributes to the selective dilatation of veins of the extremities.

*Type of Vein.* The varicose veins of pregnancy are of two distinct types. We see large veins of varying caliber, some very superficial, but many deeply situated (the varicosities usually present in the non-pregnant state) which involve the internal and external saphenous systems. There is also a second type of varicosity, superficial in character, following no definite system, but occurring at any place in the leg or thigh, and having the appearance of a collection of blood sinuses, purplish-blue in color. These collections of veins appear to communicate with a single vein which is not particularly enlarged. They are characteristic of pregnancy and disappear entirely at its termination. We have never observed them in the non-pregnant state; they are so characteristic that a diagnosis of pregnancy may be made whenever they appear. Such veins cause a good deal of pain, are frequently tender, and produce heat and itching in the affected part. A more detailed study of this type of varicosity is contemplated.

*Location of Varicosities.* There is no regular or characteristic distribution of the veins. They occur in scattered groups in different parts of the legs and thighs and appear to have no continuity. Both extremities appear equally involved and in many cases there is a more marked increase in size and number of veins in the thighs as compared to the legs. A frequent site of varicose veins is the vulval region, where they cause a great deal of discomfort. In our series of cases, we have found vulval varicosities to be usually limited to one side, rarely bilateral.

*Symptoms.* The most common symptoms are pain and cramps in the legs and thighs, a feeling of heaviness and weariness,

especially at night, a marked itching, and occasionally a burning sensation in the region of the varicosities. There is frequently swelling of feet, ankles, legs and thighs to varying degree. Veins in the vulval region produce pain, local heat, itching and a sense of heaviness and weight. In some patients these symptoms are so marked as to produce interference with walking and even discomfort while sitting.

*Treatment.* As above pointed out, very little has heretofore been done. Surgery is rightly considered contraindicated and treatment has been conservative. Support of the legs with bandages or rubber stockings, and rest in bed when the veins were very large and edema of the legs was marked, were recommended. Treatment by injection was withheld from the pregnant woman. Pregnancy was, and still is, considered a contraindication by many, although it is being recommended by a few with reservations. There is a fear of embolism and of possible interference with the normal course of pregnancy. Some men are unwilling to treat a condition which might spontaneously clear up at the termination of pregnancy.

The fear of embolism, however, has been definitely dispelled, and it is certainly a wise and judicious form of treatment which will relieve a woman of so much discomfort lasting over a period of from three to six months, especially when the treatment itself is so simple and is attended by practically no risk.

*Technique.* Our technique is very simple, yet effective. The skin is sterilized with 70 per cent alcohol. The vein is injected while the patient is in the upright position, standing on a broad platform with a railing around it for support. This position makes possible the distention of the veins and the easy entrance of the needle. We use no tourniquets and we avoid making too many maneuvers. Where the veins are very large and entrance into them is relatively easy, the patient may be placed in a sitting or recumbent position. Our only purpose

is to get into the vein and to see that obliteration does take place.

After injection, a dry gauze sponge is applied at the site and compression is maintained by adhesive strapping. An Ace pressure bandage, is applied from the toes to the knees, and is worn by the patient during the period of treatment.

The injection is repeated the following week, but the interval may be shorter and there is no contraindication to giving the treatment as often as every other day. We begin our injections below and ascend up the leg and thigh, but for practical purposes it makes little difference where one begins—obliteration takes place at the site of injection and involves a certain segment of vein. All visible and palpable dilated veins in the foot, leg and thigh are injected. Varicose veins in the groin and vulva are treated in the same manner.

*Materials Used.* The solution used is a mixture of equal parts of 30 per cent sodium chloride and 50 per cent glucose. The amount at any one treatment is 10 c.c., usually given in one injection. A smaller amount suffices for the obliteration of the small and very superficial veins. We prefer this mixture of sodium chloride and glucose to any other sclerosing solution because it produces no constitutional disturbance, a very important consideration in a pregnant woman.

There is an excellent obliteration with relatively little phlebitis or perivenitis. The pain or cramp at the time of injection, while sharp and intense, is very short in duration and disappears before the patient has her pressure bandage applied. There is practically no discomfort after she leaves the clinic. On the other hand, there is the possibility of induration and slough formation when small amounts of this solution infiltrate the subcutaneous tissue, but this accident can be and should always be avoided.

In a group of thirty cases, we have injected a 5 per cent solution of sodium morrhuate. In this small group we found that the obliteration, while excellent, was

accompanied by a good deal of phlebitis and perivenitis. The injection was not immediately accompanied by pain or cramp, but considerable pain and discomfort began several hours to several days after the injection and continued for many more days. There is, moreover, the danger of a constitutional reaction manifested by collapse with cyanosis, dyspnea; low blood pressure, generalized urticaria, and gastrointestinal disturbances. This reaction we have observed in several cases of males and non-pregnant women. It would be particularly undesirable in a pregnant individual.

A 10 c.c. luer syringe is used, to which is attached a 21-gauge needle  $1\frac{1}{4}$  inches long, with medium size bevel. For very small veins we use a 23 to 25-gauge needle. We deliberately choose a large caliber needle to insure ease in injection with little danger of spilling into the tissues. The quick and easy flow of blood back into the syringe and the same very easy flow of sclerosing fluid into the vein with little pressure on the plunger of the syringe can only be obtained when a large needle is employed. This precaution must be taken when one uses a solution that will produce a slough if even a small amount infiltrates the soft tissue. There is, however, no danger of leakage from the puncture in the wall of the vein. Solution may leak into the tissues if the vein is transfixed, or in the process of withdrawing the needle. Great care should therefore be used in aspirating blood before any solution is injected *and also* before the needle is withdrawn from the vein.

*Time of Injection.* Varicose veins may be injected at any time during pregnancy, from their first appearance until practically the termination of the period. But inasmuch as the treatment is ambulatory and it is desirable that the patient remain on her feet after injections are given, we avoid treatment in the last month of pregnancy.

*Number of Injections.* There is no limit to the number of injections that may be given, since this depends upon the amount

of involvement of veins and upon the time still left before delivery. In our series of cases one patient received as many as twenty-five injections.

Table I gives a survey of our cases

TABLE I	
Number of patients observed.....	1017
Number of patients injected.....	731
Number of patients reporting some discomfort following injection...	86
Perivenitis.....	
Induration.....	
Ulceration.....	
Number of patients receiving injection in vulval veins.....	92
No. of Injections	No. of Patients
1	192
2	154
3	112
4	75
5	57
6	40
7	24
8	20
9	16
10	12
11	5
12	9
13	3
14	3
15	5
16	3
25	1
Total.....	731

**Results.** With practically no exception, there was decided improvement in all our cases. The pain, cramps, heaviness of extremities and fatigue disappeared. All the veins that were injected were obliterated, the swelling of foot and leg disappeared, and the normal contour of the extremities was restored. In most cases, after the first injection, long before there was a definite change in the appearance of the extremity, there was an improvement in the symptoms.

Obliteration of the veins was easily obtained and with remarkably little reaction as compared to the cases I observed in the non-pregnant woman. There was no vein so largely dilated that it did not yield to obliteration. All our patients obtained a more comfortable ante-partum course. There was an absence of discomfort during

labor. In a few cases where there had been some pain in previous labors, evidently from straining and pressure, there was no such complaint after treatment. There was no post-partum phlebitis in our series of treated cases, and there was a complete absence of varicosities post-partum in those who had received sufficient treatment before delivery. These last few facts are evidence of the prophylactic value of our treatment.

**Varicosities of the Vulva.** We have treated ninety-two patients presenting varicosities of the vulva, and in all but two there was obliteration with only one injection. About 5 c.c. of solution was used and the patient in a recumbent position. The patient experienced a very sharp pain in the region of the vulva with occasional radiation down the groin and thigh. This pain lasted only a minute or two and then entirely disappeared. Compression at the site of the injection was maintained by a vulval pad and the patient was allowed up when there was no evidence of bleeding at the site of injection.

There were no complications. In only two cases was there some tenderness to pressure over the obliterated thrombosed veins, but this fact gave little discomfort as compared with the pain, sense of weight, heaviness, itching and heat, which were the complaints in these cases.

**Complications. Phlebitis.** There were no unusual nor unpleasant complications because of the fact that our patients were pregnant women. There was no interference with pregnancy, and no untoward results occurred after delivery. There were, however, a few cases with phlebitis and perivenitis due to the irritating action of the solution, a condition which likewise occurs in the non-pregnant group.

In only six instances was there much disability and these occurred among the first cases we treated. Since then we have been able to relieve this complication by a very simple form of treatment which gives very prompt alleviation and permits the

patient to continue her activities without discomfort. While I claim no originality for it, I have seen no record of this treatment in the literature and I offer it for what it is worth. The area of involvement or induration is firmly compressed and strapped by strips of adhesive. These strips (about 1 to 1½ inches wide) are firmly placed around the part, beginning about an inch or two below the point of phlebitis or induration. Care is taken not to encircle completely the leg or thigh involved. Each successive strip is placed above the other so that it overlaps the preceding one for about half its width. This process of overlapping adhesive strips continues until the area of induration is completely covered and an additional area of about 1 to 2 inches above it is included. There is naturally some pain while these strips are applied, but the immediate relief is almost miraculous. The patient is able to walk about with little discomfort and is prepared for a continuation of her treatment.

*Slough and Ulceration.* We have had several cases in which sloughing and ulcers appeared at the site of injection due to infiltration into the surrounding tissue. These cases are not considered complications of the treatment but rather accidents due to faulty technique and in our series of cases occurred in the hands of inexperienced assistants. These accidents should not occur, and with more experience on the part of the operator, do not. We employ a very simple rule in the hope of avoiding this accident. If there is the slightest doubt as to whether the needle is in the vein, regardless of the appearance of blood in the syringe, we strongly advise against injection. It is wiser to withdraw the needle and seek another site for injection. The slightest evidence of pain or a burning sensation when not more than one drop is injected should halt the injection. There is no immediate painful sensation when the solution is properly injected into the vein.

If infiltration does occur, about 5 to 10 c.c. of normal saline is injected into the

surrounding tissue. If induration occurs, it will be relieved by the method of adhesive strapping as described for phlebitis. If a slough occurs it should be excised and the resulting ulcer treated by this same method. Healing takes place with very little scarring.

*Some Interesting Observations.* We have been able to make a number of interesting observations during the course of treatment of these cases. We have noticed that:

1. Obliteration by injection of sclerosing solution was more effective and complete than in the non-pregnant; fewer injections were required. The probability is that these newly formed veins are more susceptible to the irritation of the solution.

2. Relief of symptoms occurred even after one injection.

3. Although the disease is progressive, yet after the injections we observed no new varicosities appearing in the treated extremity.

4. There were no cases of post-partum phlebitis in our treated cases. I can recall four patients who failed to report for treatment and in whom phlebitis occurred during the post-partum stage. We feel certain that these cases could have been prevented by ante-partum treatment.

5. We have observed a distinct type of varicosity not seen in the non-pregnant woman, whose presence should suggest a diagnosis of pregnancy. We hope to make a further study to substantiate this observation.

6. General concepts of the cause of varicose veins in pregnancy need modification; pressure upon the internal iliac vessels is not a factor; some toxin or hormone is present to bring about the dilatation of veins.

7. All women are potential varicose vein cases; no woman appears exempt; varicosities may appear very early in childbearing period, but in many cases not until the woman has had a large number of pregnancies.

8. Relatively large number of pregnant women have varicosities.



## CONCLUSIONS

1. Varicose veins produce more discomfort and pain than is realized and for that reason should be actively treated.
2. Pregnancy is no contraindication to the injection treatment and treatment may be given from the first to the ninth month of pregnancy.
3. Relief of symptoms is quickly obtained.
4. There is an important prophylactic value of the treatment in the prevention of post-partum phlebitis and the disappearance of varicosities during the post-partum state.
5. It is probable that recurrence of veins with subsequent pregnancies will be less marked and less troublesome. This conclusion cannot be definitely established but will be determined by our follow up and a subsequent report of our treated cases. We have had an opportunity to follow a few cases during a subsequent pregnancy but these are too few upon which to base any worth while conclusions.

I wish to acknowledge my appreciation to Dr. Samuel A. Cosgrove, Medical Director of the Margaret Hague Maternity Hospital for advice and help in the development of the Varicose Vein Clinic and in the preparation of this report.



THE major troubles that may affect the foundation of the body, the feet, are in the order of their incidence, (1) the weak, or flat foot; (2) depression of the anterior arch, contracted toes, anterior metatarsalgia or Morton's toe; (3) hallux valgus, or bunion.

From—"From Head to Foot" by Armitage Whitman (Farrar & Rinehart).

# THE TREATMENT OF AMENORRHEA OF ENDOCRINE ORIGIN\*

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THE treatment of amenorrhea has remained a perplexing problem, whether the amenorrhea be primary, menstruation never having been initiated, or secondary, the function having ceased in a previously menstruating woman.

It is now well known that normal menstruation depends on the action on the endometrium of the two hormones, estrone and progesterone, produced by the ovary as a result of pituitary stimulation. It is necessary to differentiate normal menstruation which occurs from a secretory or premenstrual endometrium from cyclical bleeding which may occur simply from a proliferative endometrium. It appears that a normal woman may exhibit either or both types of bleeding corresponding respectively to the ovulatory and anovulatory cycles in the macacus rhesus monkey. Cyclical bleeding has been produced in castrated women by the administration of estrone (Werner and Collier), but if estrone is given first and followed by progesterone, true menstruation from a premenstrual endometrium may be brought about (Kaufman).

It has been suggested that the onset of menstruation is due to a specific hormone or "bleeding factor" acting directly on the uterus and arising from the anterior pituitary or some other source. In support of the theory of pituitary origin, it has been noted (Kurzrok, Kirkman and Creelman)

that gonadotropic hormone appears in the urine during the first day of the period, indicating pituitary activity at this time. More recently, bleeding has been produced in hypophysectomized monkeys by the injection of estrone (Smith, Tyndale, Engle). This work and the production of bleeding in castrated women by estrone administration would seem to indicate that neither the pituitary nor the ovary is necessary to produce uterine bleeding. It is felt that the endometrium itself is the most likely source of the "bleeding factor."

The simple presence of the proper hormones in the circulating blood of a woman is not always sufficient to produce menstruation. It is necessary to have a uterus which is capable of responding to the stimulation of these hormones. This is not the case in many amenorrheic women, who often exhibit genital hypoplasia of a marked degree. In these patients, the hormone level may be quantitatively within normal limits but no menstruation occurs due to the failure of the uterus to develop to an extent sufficient to respond to hormonal stimulation. However, large doses of estrone may build up such uteri to a point where they are able to respond again to the hormonal influence of their own ovaries.

It is clear from the multiplicity of factors concerned in the menstrual cycle, that successful therapy must rest on a careful

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and accurate diagnosis of the particular defect in each case. Attempts simply to treat symptoms without determining the underlying causes are doomed to failure and can only bring discredit to endocrine therapy.

The problem before us is to determine whether the patient's ovaries are functioning, and if so, whether normally or sub-normally. If this function is impaired, is the defect primarily in the ovary or secondary to a primary defect in the function of the pituitary, thyroid or other gland? Is the end organ (uterus) normally developed? Is the general health of the patient a contributing factor?

Investigation should follow a definite plan. A careful history is taken and a general physical examination done, noting skeletal development, presence and type of obesity, hair distribution and secondary sex characteristics. Note is made of the development of external genitals, vagina and uterus. Eyegrounds are examined and visual field determinations done where indicated. Laboratory tests include basal metabolic rate, sugar tolerance, blood count, blood cholesterol, x-ray of sella tursica, determination of hormone content of the urine, and endometrial biopsies.

Histologic examination of the endometrium at stated intervals is probably the most important diagnostic procedure at our command. This is easily done without anesthesia, using a small suction cannula curette. The procedure is based on the work of investigators (Hitschman and Adler, and others) who correlated the cyclic changes in ovaries and uterus and showed that the uterine mucosa reflects accurately the changes occurring in the ovary. Where the normal ovarian function is disturbed, the endometrial cycle shows a corresponding deviation from normal.

Hormone determinations done on the urine may show one of four responses (Kurzrok). These are:

1. Prolan absent, estrone present. This is a normal finding. If found during amenorrhea, it means that both the pituitary and

ovaries are functioning, and amenorrhea may be simply due to hypoplasia of the uterus.

2. Prolan absent, estrone absent. This means lack of ovarian function, probably secondary to pituitary failure.

3. Estrone absent, prolان present. This is significant of ovarian failure with pituitary activity. It is a common finding in the menopause.

4. Estrone present, prolان present. This is the normal finding just preceding ovulation. It is an unusual finding in amenorrhea but may be present early in the menopause.

*General Data.* This report deals with observations made on twenty patients with amenorrhea. Patients were observed for a period of from four to twenty-seven months. There were eighteen cases of secondary amenorrhea and two of primary amenorrhea. In the secondary cases, duration of amenorrhea ranged from four months to ten years. Ages of the patients varied from 16 to 32 years. Most of the patients had had some sort of therapy attempted before coming to the clinic.

*Therapeutic Measures.* 1. Attention to General Health. An attempt was made to investigate and correct any deficiencies in the general health of the individual. This included treatment of anemia, obesity, malnutrition and vitamin deficiency, also the treatment or removal of obviously infective foci.

2. Estrogenic Hormone. It has been definitely demonstrated that estrone stimulates the growth of uterine muscle. Most cases of amenorrhea of any duration, regardless of the primary cause, show some degree of uterine hypoplasia. These atrophic uteri are incapable of normal function. When large doses of estrone are given, definite enlargement of the uterus occurs and proliferative changes take place in the endometrium which are followed by bleeding.

Since the pituitary and ovary have a reciprocal activity, it has been claimed that administration of large doses of estrone should inhibit pituitary activity, whereas

stopping the estrone therapy should release the pituitary to flood the circulation with its hormones. This "pituitary release" phenomenon has been cited (Holweg) to explain the uterine hemorrhage which occurs after large doses of estrone. Corpora lutea have been produced (Clauberg) in the ovaries of infantile mice by the administration of estrone, indicating pituitary activity through "release phenomenon." On the other hand, suppression of ovulation has been produced experimentally (Hisaw) by continued administration of large doses of estrone, probably due to pituitary depression.

Thirteen patients were treated with estrogenic hormone, given intramuscularly in the form of progynon-B (Schering) and amniotin (Squibb). Dosage varied from 10,000 international units weekly to 50,000 i.u. twice weekly, and total dosage from 170,000 i.u. to 2,705,000 i.u.

In every case where atrophy of the uterus was present, enlargement of this organ was accomplished, in many cases to normal size. Occasionally, extensive and prolonged treatment was necessary before uterine growth was initiated. In cases where therapy was discontinued and menstruation did not persist, rapid involution of the uterus occurred and in a short time, a return to the original atrophic condition was noted. Reinstitution of treatment in these cases again produced uterine growth.

Of the thirteen patients treated with estrone (two primary and eleven secondary), bleeding was brought about in all cases. One patient became pregnant while under therapy after eight months of amenorrhea. In this case, true menstruation and not simply cyclical bleeding was produced. Four patients continued to menstruate regularly after therapy was discontinued. All four were cases of secondary amenorrhea. One of these patients became pregnant following four normal menstrual periods after treatment was stopped.

Bleeding occurred during the constant administration of estrone, in most cases at

intervals of about one month. Bleeding also occurred within a short time following withdrawal of the hormone. Normal premenstrual molimina were associated with bleeding, breast enlargement occurred regularly and occasionally the breasts were painful. A very prominent feature was the marked improvement in the mental condition of these patients with the onset of cycles of bleeding. They were much happier, took a greater interest in life and felt that they were no longer set apart from other women. We have not seen the severe headache which has been noted (R. Kurzrok) following administration of large doses of estrone.

3. Progesterone. To produce true menstruation in amenorrheic women, it was found necessary (Kaufman) to give estrone (250,000 i.u.) during the first half of the cycle, followed by progesterone (35 i.u.) during the latter half. In this study, we have not attempted to produce menstruation in this manner because of the difficulty in obtaining the large amounts of the hormone required and because of the purely substitutive nature of the therapy.

4. Gonadotropic Hormone. This type of therapy would seem to be ideal where the ovary has failed and the pituitary is inactive. When the urine or blood show an increased amount of prolactin, indicating full pituitary activity, gonadotropic hormone is obviously valueless. In addition, it must be realized that, where pituitary deficiency has been demonstrated, the use of gonadotropic extracts to stimulate ovarian function is at best a therapy of purely substitutive nature, as these extracts have no effect on the pituitary gland itself.

It has been shown (Geist; Hamblen and Ross) that the present available pregnancy urine extracts do not produce follicle development in humans. Patients were injected with antuitrin-S before operation for uterine fibroids and it was found at operation that primordial follicles were not stimulated but that there was an arrest of follicular development with formation

of follicle cysts. Recently, pregnant mare's serum has been used as a gonadotropic agent. However, failure in producing menstruation has been reported (Frank et al.) in four cases using doses of 60 to 510 rat units.

In this study, gonadotropic hormone derived from pregnancy urine (follutein, Squibb and antophysin, Winthrop) was used where the diagnosis of pituitary failure was made, together with aqueous extract of the pituitary gland (Squibb). Five patients were treated in this manner (all secondary amenorrhea). In two cases, treatment failed completely. One patient menstruated once after two and one-half months of therapy with 200 rat units weekly. Another menstruated for a period of one year while under treatment, receiving 200 rat units weekly. The fifth patient, after fourteen months of amenorrhea, menstruated from a premenstrual endometrium following administration of 800 r.u. of gonadotropic hormone combined with 8 c.c. of anterior pituitary aqueous extract given over a period of one month, together with a small amount of thyroid. Another period occurred three months later under continued therapy in the same dosage. Two and one-half months after this, the patient was found to be two months pregnant and was delivered at term of a normal child. Following delivery, the patient menstruated regularly for a period of six months when amenorrhea again occurred. Therapy for two months has been unsuccessful to date.

5. Thyroid. Thyroid therapy is indicated where there is a reduction in the basal metabolic rate. This may be primarily due to thyroid deficiency or secondary to deficiency of pituitary thyrotropic hormone. In most cases, thyroid was given in conjunction with some other form of therapy.

In connection with thyroid therapy, it would be well to mention a condition which has been called "nutritional hypothyroidism" (?). It occurs as a rule in young girls who believe themselves to be

too fat and undertake rigid reducing diets. These diets are low in fats and carbohydrates and high in proteins. The patients lose weight but become tired, listless and "run down" and soon develop amenorrhea. Basal metabolic rate is low and estrone is absent from the urine. Administration of thyroid and estrone fails to help these patients, but a cure is soon effected by giving a high caloric diet, high in fats, carbohydrates and vitamins.

6. X-ray. Low dose irradiation (stimulating doses) of the pituitary or ovary has been used with some success. In forty-nine amenorrheic women, Mazer and Spitz were able to reestablish periodicity in 49 per cent. Of three patients with primary amenorrhea, one gave a satisfactory result. I. I. Kaplan recently reported 117 cases of secondary amenorrhea treated by irradiation of ovary, pituitary and thyroid with good results in 67 per cent.

Experimental work (Scholz) on dogs has indicated that radiation of brain tissue is not unassociated with danger. Multiple areas of necrosis were found, with marked degenerative changes in the intracerebral blood vessels of young dogs exposed to 1 or 2 erythema doses. Clinical changes were apparent after a latent period.

In this series, x-ray stimulation of the ovaries was attempted in three cases. In none of these were we able to produce bleeding. X-ray stimulation of the pituitary was not attempted.

7. Dilatation of the Cervix. One of us (C. H. B.) has recently demonstrated a pituitary response to dilatation of the cervix, indicated by the appearance of prolan in the urine shortly after this procedure is done. In addition, we have noted that in patients with hypomenorrhea and oligomenorrhea, endometrial biopsies often resulted in generous menstrual periods. It is believed that these are the result of pituitary stimulation produced by the dilatation of the cervix incidental to the biopsy.

With this in mind, an attempt was made to stimulate gonadotropic activity in this

manner when the diagnosis of pituitary failure was made. As many of our patients are virgins, this procedure was used in only two cases. In one, weekly cervical dilatation with Hegar dilators produced two menstrual periods at an interval twenty-eight days after two years of amenorrhea. In the other, repeated cervical dilatations over a period of four months produced two periods after other methods of therapy had failed to produce bleeding. Following this, the patient bled every month for five months and then became pregnant after twelve years of sterility.

#### CASE HISTORIES

CASE I. B. S., age 24, complained of amenorrhea for six months and sterility for two years. Her periods began at 12 years, were regular until two years before examination, then became irregular and finally stopped. The patient was obese with girdle distribution and male escutcheon. The breasts were obese but underdeveloped, the external genitals atrophic, uterus small, vagina shallow. The basal metabolic rate was minus seven. Urinary estrone was negative and prolactin positive. Three endometrial biopsies at weekly intervals showed mid-interval endometrium. X-ray of the sella was negative. A diagnosis of ovarian failure was made.

Therapy consisted of the administration of estrone, 10,000 i.u., twice weekly, thyroid 3 gr. daily, and dietary restriction. Under this régime, the patient bled monthly for a period of five months. Treatment was discontinued and the patient continued to menstruate. After four normal periods, amenorrhea again developed and the patient was found to be pregnant.

CASE II. M. M., age 22, single. This patient had never menstruated except for slight bleeding six years before. She was thin, fair skinned, of feminine demeanor and female escutcheon. The breasts were normally developed. The external genitals were atrophic, the uterus and cervix about 1 inch long. Basal metabolic rate was plus 1 per cent. X-ray of the sella was normal. Urinary estrone was negative, prolactin positive. Endometrial biopsy was not done. The sugar tolerance test was normal; blood cholesterol 131. A diagnosis of primary ovarian insufficiency was arrived at.

Therapy consisted of administration of estrone, 50,000 i.u. twice weekly. Bleeding began within two months and continued at intervals of five or six weeks. The uterus grew to normal size, the breasts enlarged and the patient's mental condition showed marked improvement. She was much happier and livelier. After one year, estrone therapy was discontinued and bleeding promptly stopped. X-ray therapy was given to the ovaries with no effect. In three months, the uterus and cervix had regressed to their original condition. With the failure of x-ray stimulation, estrone was again given. The patient began to bleed within one month and the uterus again enlarged to normal size. This patient received a total of 2,700,000 i.u. of estrone.

CASE III. J. G., age 28, married ten years. She had begun to menstruate at 12 years of age, but periods were always irregular, and she had been amenorrheic for fourteen months. Two living children had been born and there had been two abortions, one spontaneous and one induced. The patient was obese with girdle distribution, had a male escutcheon, obese breasts, normal external genitals. The uterus was normal in size. The basal metabolic rate was minus 10 per cent. X-ray of the sella appeared normal, and the visual fields were also normal. Urinary estrone was negative, prolactin negative. Endometrial biopsy showed a resting endometrium. The diagnosis was hypopituitarism.

Therapy consisted of 200 r.u. of gonadotropic hormone weekly plus 2 c.c. of aqueous pituitary extract and  $1\frac{1}{2}$  gr. of thyroid daily. After one month of treatment, patient bled and biopsy showed premenstrual endometrium. Continued treatment resulted in another period three months later; two and one-half months after this, the patient was found to be two months pregnant. Pregnancy went to term and a normal child was delivered. Following delivery, patient menstruated regularly for a period of six months and then became amenorrheic again. Therapy for two months has been unsuccessful to date.

CASE IV. C. G., age 20, married, had had amenorrhea for fifteen months and had gained 100 pounds in two years. She began to menstruate at 14 years of age, and had always been irregular. She was tall, obese, with girdle distribution, had coarse hair of male distribution and was sluggish in appearance. The

breasts were obese, the external genitals, cervix and uterus normal. The basal metabolic rate was minus 6 per cent. X-ray of the sella tursica was normal. Blood cholesterol was 209, and the sugar tolerance was increased. Urinary estrone and prolan were both negative. Endometrial biopsy showed an interval endometrium. Hypopituitarism was considered the difficulty.

Therapy consisted of 200 r.u. of gonadotropic hormone plus 2 c.c. of anterior pituitary extract weekly with thyroid 3 gr. daily and diet of 800 calories. Patient was treated for four months without result except for some loss of weight. Cervical dilatation at weekly intervals was done in an attempt to stimulate pituitary gonadotropic activity and two periods were produced at intervals of twenty-eight days. Dilatation was then discontinued and the patient ceased to menstruate.

CASE V. R. B., age 32, married, had been amenorrheic for five years and sterile for twelve years. Her periods began at 16 years of age and always were irregular. She had gained 35 pounds in weight in two years. Obesity of girdle distribution was present, with male escutcheon and normal external genitals. The entire uterus was 1 inch in length. The basal metabolic rate was minus 2 per cent, the sugar tolerance normal, urinary estrone and prolan negative. X-ray of the sella was normal. Blood cholesterol was 220 mg. Repeated endometrial biopsies showed an interval endometrium. Diagnosis: Hypopituitarism with genital hypoplasia.

Therapy consisted of low caloric diet and thyroid  $1\frac{1}{2}$  gr. daily. Estrone 50,000 i.u. was given twice weekly for a period of one month to produce uterine growth. The uterus enlarged practically to normal size, but no bleeding occurred. Cervical dilatation was then done at weekly intervals for four months and bleeding was produced twice at an interval of two months. Therapy was discontinued, except for a small dose of thyroid, and the patient continued to menstruate at monthly intervals for five months. She became amenorrheic again, was found to be pregnant and was delivered at term of a normal child.

CASE VI. A. J., age 25, single, was amenorrheic for four years. Her periods began at 14 years of age, were regular until six years before, then became irregular and finally stopped four years before. This patient was tall and thin, with feminine demeanor, slight hirsuties of face and extremities, female escutcheon, atrophic breasts, and normal external genitals. The

entire uterus was about 1 inch long. Endometrial biopsy was not done. Urinary estrone was negative, prolan positive. The basal metabolic rate was plus 4 per cent. X-ray of the sella was normal, as was sugar tolerance. Blood cholesterol was 228 mg. Diagnosis: Ovarian (secondary) failure with genital aplasia.

Therapy consisted of estrone, 50,000 i.u. weekly. Bleeding was produced in six weeks but no enlargement of the uterus. Estrone dosage was increased to 50,000 i.u. twice weekly. After four weeks, patient bled profusely for 2 weeks and uterus was found to have grown to approximately normal size. Estrone was continued in dosage of 50,000 i.u. weekly and the patient continued to bleed for three or four days at intervals of about one month. A very distinct change took place in her personality. Whereas before therapy she had been retiring, moody and often depressed, she became happy, alert, lively and aggressive. Definite enlargement and development of the breasts has occurred. This patient is still under treatment.

#### SUMMARY

Careful investigation and accurate diagnosis are a prerequisite for successful therapy in amenorrhea of endocrine origin.

Twenty cases of amenorrhea were treated with various therapeutic agents. Of thirteen patients treated with estrogenic hormone, bleeding and enlargement of the uterus with improvement in secondary sexual characteristics was produced in every case. One patient became pregnant while under treatment after eight months of amenorrhea. Four patients continued to menstruate after treatment was discontinued, and one of these subsequently became pregnant after three years of sterility.

Gonadotropic hormone was used in five cases and bleeding accomplished in three. One of these three later became pregnant.

X-ray, in stimulating doses to the ovaries, has been unsuccessful in three cases. However, as this was used only in those cases where vigorous therapy by other methods had failed, this poor result is not so significant as if the cases had been unselected.

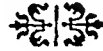


Dilatation of the cervix to produce menstruation through pituitary stimulation was successful in the two cases in which it was attempted. One of these patients later became pregnant after twelve years of sterility.

We wish to thank the Schering Company, E. R. Squibb and Sons, and the Winthrop Chemical Company for their coöperation in supplying the large amounts of endocrine products used in this study.

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THE surgical treatment of goiter has produced abundant material capable of establishing beyond controversy the fact that the goitrous disease is from first to last a disease of the thyroid gland. Basedow's disease without changes in the thyroid gland does not exist.

From—"Diseases of the Thyroid Gland" by Arthur E. Hertzler (Mosby).

# TRICHOMONAS VAGINALIS VAGINITIS

## FURTHER STUDIES IN THE USE OF IODOCHLORHYDROXYQUINOLINE\*

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IN 1937, the author<sup>1</sup> reported a series of thirty-eight cases of trichomonas vaginalis vaginitis treated with vioform ointment (Ciba). Since that report, an additional seventy-one cases have been treated, using the same technique. Three of the total of 109 patients did not remain under treatment, and therefore are not included in this report.

Our experience with the original technique has revealed some disadvantages which should be discussed: (1) scrubbing the vagina with green soap in the acute cases of vaginitis is very painful, and, at times, impossible without the use of a general anesthetic; (2) there is a prolonged spread of the ointment over the vagina and vulva which makes wearing of a pad imperative to protect the clothing. The pad is very irritating to an already inflamed area.

There are two features which favor the use of the ointment: (1) the exceptionally high percentage of cures effected. (2) the rapidity with which subjective symptoms subside.

Following the publication of the preliminary report of this technique, a series of determinations of the hydrogen ion concentration of vaginal secretions was compiled, using unselected patients without trichomonas vaginalis (normal), and patients with trichomonas vaginalis vaginitis (pathologic). The ratio between the normal and pathologic cases was approximately two to one.

The method of determination was as follows: the vaginal tract was thoroughly flushed out with 10 c.c. of normal saline solution with a pH of 7. Care was taken to recover all of the flushing solution. The specimen was centrifuged to remove suspended organic material, and the solution compared with known standards in a colorimeter, as shown in Table II.

TABLE I

Number of cases.....	106
Cures	
Number.....	104
Per cent.....	98.1
Failures	
Number.....	2
Per cent.....	1.9
Recurrences	
Number.....	7
Per cent.....	6.7

Two patients were treated, not only with vioform ointment, but with carbarsone, silver picrate, and floraquin. In spite of all this treatment, cures were not effected. The only conclusion which can be drawn from these failures is that none of the methods of therapy eradicated the primary source of the infestation.

Seven of the patients treated were pronounced cured, as judged by the standards laid down by Adair and Hesseltine,<sup>2</sup> and by Angelucci,<sup>3</sup> but after varying periods of time the condition recurred. Cure indicates that the patient (without treatment) "has passed through two menstrual periods without recurrence of symptoms, and there is no evidence of the disease on clinical appearance or smear." Recurrences were treated by a modification of the vioform technique which will be discussed later.

TABLE II

Range of pH	Indicator
4.6-5.4	Bromeresol
5.2-6.8	Chlorphenol
6.8-8.4	Phenol red

\* The author wishes to express his appreciation to the Ciba Pharmaceutical Company whose cooperation has made this study possible. He also wishes to thank Dr. Norman A. David, Professor of Pharmacology, University of Oregon School of Medicine, and Fred J. Kohlruess and Arthur Istvanovich, both of the University of Portland College of Science, for assistance rendered during the course of this study.

While this method is not so exact as would be the use of an electric potentiometer, still it gives a fairly accurate reading which is the average for the entire vaginal tract.

The results of the determinations on a series of 200 patients (a total of nearly 400 determinations) are given in Table III.

TABLE III

	pH Range for Group	pH Average for Group
Normal.....	4.6-7.5*	6.2
Vaginitis.....	4.0-5.0	5.0

\* Only one reading above pH 6.8 was encountered, rising from pH 4.8 during the disease to pH 7.5 following treatment for vaginitis.

In general, it was found that the more acute the vaginitis and the greater the number and the more active the organisms, the lower was the hydrogen ion concentration. It was hoped that a rise in the hydrogen ion concentration of the vaginal tract would make the environment as unfavorable as possible for the parasite. The aim was to raise the pH of the vagina, and, even more important, to maintain the new level for the longest possible time.

Magnesium trisilicate powder was considered the most effective agent for this purpose. Vioform, an efficient protozoacide,<sup>4</sup> which is more effective in an alkaline medium, was added. The two powders were combined in the proportion of one part vioform and nine parts magnesium trisilicate, approximately 50 gr. being used per treatment.

The treatments were carried out tri-weekly by means of a Shelanski<sup>5</sup> insufflator. At first they were discontinued during the menses, but recently continuous treatments have been given, resulting in more rapid cure. It is not necessary to scrub the vagina before treatment except during the menses. At that time the vagina is irrigated with 25 per cent salt solution,<sup>6</sup> dried with cotton, and insufflated.

The results obtained were:

Cases.....	140
Cures	
Number.....	137
Per cent.....	97.8
Recurrences	
Number.....	3
Per cent.....	2.2

In patients who received vioform by mouth in addition to vaginal treatment with vioform powder, the results were:

Cases.....	112
Cures	
Number.....	112
Per cent.....	100
Recurrences.....	0

Where vioform powder was given only vaginally, there were:

Cases.....	28*
Cures	
Number.....	25
Per cent.....	89.3
Recurrences	
Number.....	3
Per cent.....	10.7

\* The series of 28 cases are bed patients at the Oregon State Tuberculosis Hospital, Salem, Oregon, who have been treated through coöperation of Grover C. Bellinger, M.D., Superintendent. We wish to express our appreciation for his helpfulness.

Fifteen patients with pruritus ani et vulvae, who had received very extensive therapy of various types prior to coming under the author's care, were also treated with vioform. Ten have been relieved of all symptoms and are pronounced cured. The remaining five are still under treatment and show marked improvement.

To date, there have been no recurrences among the patients treated with vioform powder and vioform orally. However, recurrences occur in from 5 to 10 per cent of the patients *where the vagina only is treated*. It is our belief that the primary source of infestation is not reached by vaginal treatment alone.

A factor in the recurrences in this series is the exclusive use of bed pans with resulting failure properly to cleanse the parts after toilet. Cases of trichomonas vaginalis vaginitis developing after surgery in well run hospitals are not due, as is

generally assumed, to poor technique on the part of the nursing staff. Rather, the author believes, the infections are due to the fact that following stool passage, it is impossible for the patient or nurse to cleanse the parts in any manner other than from the rectum over the vulva, thereby favoring vaginal infection where the organisms are present in the intestinal tract.

Vioform has been used in combination with glycerin in the treatment of trichomonas vaginalis vaginitis, with remarkable success. Huffman<sup>7</sup> reports a series of fourteen cases treated with a 6.6 per cent suspension of vioform in glycerin with 100 per cent cures. Peterson<sup>8</sup> treated a series of 500 cases with a paste of 15 Gm. of vioform in 22 c.c. of glycerin, with cures in 99.8 per cent. Seven of his series were refractory to other forms of treatment but were cured with vioform paste.

The advantages of the powder therapy over the vioform ointment appear to be:

1. Magnesium trisilicate is very efficient in rendering the environment (vagina) unfavorable to the trichomonas by elevating the hydrogen ion concentration.
2. There is not so much soiling of the clothing when vioform powder is used, as compared to the ointment.
3. The cost of treatment is very much less than with any other form of therapy that is to be considered equally effective.
4. Vioform is very slightly if at all toxic in any dosage.

No untoward (toxic) effects have been noticed in our clinical experience with vioform, nor has a search of the literature revealed any reports of unfavorable reactions—whereas reports are available of toxic reactions to other preparations used in the treatment of this condition.

Several of the most popular compounds used in this condition are arsenicals. It is known that the rate of absorption of arsenic from the vagina is nearly as great as from the gastrointestinal tract. Therefore, the possibility of intolerance to arsenic must always be borne in mind when one of these compounds is used.

Campbell<sup>9</sup> has reported a case of arsenical intolerance in which systemic reaction and exfoliative dermatitis developed. The patient had been treated for lues several years before with acetphenarsine (109) and had developed symptoms of intolerance. Serology was negative for two years preceding an attack of trichomonas vaginalis vaginitis. After 40 gr. of stovarsol had been administered vaginally over a period of five days, the patient developed acute symptoms of arsenical intolerance, and was hospitalized with an exfoliative dermatitis.

Schauffler<sup>10</sup> observed three cases of intolerance to an arsenical preparation (devegan) when administered intravaginally. Epstein<sup>11</sup> reports a death from acute arsenical degeneration of the liver where a total of only 5.0 Gm. of carbarsone was given to a woman for amebiasis.

Silver picrate is also capable of producing toxic reactions, both local and systemic. The manufacturers of the compound warn against the use of alkaline douches or tub baths, while silver picrate is being used. Silver picrate, in the presence of an alkali, decomposes into free silver and picric acid.

Mrs. R. W., complained of vaginal discharge, burning and itching of the perineum, vulva and vagina, and pain in the lower abdomen. On examination, she was found to be suffering from an acute trichomonas vaginitis, complicating a cystocele, rectocele and laceration of the cervix. She also had a retroversion of the uterus and chronic appendicitis.

As she lived some distance away and could report for treatment only at intervals of a week or more, it was decided to use silver picrate to clear up the vaginitis. She was given one insufflation in the office, and instructed to use a 2 gr. suppository each night for six nights. On the third day there developed a severe burning of the vagina, vulva and perineum, accompanied by marked swelling. The next day, the condition had extended over the entire body, and there was unbearable general pruritus, accompanied by generalized erythema. The patient was hospitalized for ten days before the symptoms subsided.

Since the vaginitis remained, devegan and later floroquin were resorted to in an attempt to eradicate the parasites. Both treatments

were without permanent results. Later, insufflations of vioform powder resulted very quickly in a cure, and after four months there has not been a recurrence of the symptoms or of the parasite in the vaginal secretion.

Recently the author has observed a similar case of silver picrate reaction through the courtesy of Dr. Thomas C. Saunders. The patient had received only four insufflations of silver picrate (by an osteopath) when she developed a generalized reaction similar to that in the case just discussed.

There are many explanations advanced for the recurrence of the condition. Husbands are frequently blamed for reinfestations occurring in their wives. The author believes that this cause is of almost negligible significance. Whenever a woman suffers a recurrence, the author requires that the husband be checked by a competent and interested urologist.<sup>12</sup> It is our belief that considerably less than 10 per cent of recurrences can be laid to sexual relations.

The other explanation offered, which seems to be most logical, is that the parasite is harbored in the rectum, and that recurrences are the direct result of the continued presence of the organism in the individual. The occurrence of the disease in infants and children lends support to this theory.

Other cases reported below also support the theory of the rectal origin of the parasite.

Baby W., aged 3 months, was brought in for examination because the mother noticed a thin purulent vaginal discharge with redness and swelling of the external genitalia. The baby had frequent, loose, irritating stools for several days before the vaginal discharge appeared. Smears from the vagina were negative for Neisserian infection. A saline suspension of the discharge revealed many active trichomonads. A similar examination of the stool revealed an organism which appeared identical. In addition to local treatment, 1 gr. of vioform was given orally for the next two weeks. On re-examination, no trichomonads were found. During the ensuing eighteen months, there has been no recurrence of the disease.

B. B., aged 4 years when the diagnosis of trichomonas vaginalis vaginitis was first made, has been pronounced cured several times following treatment with many techniques and drugs. The patient was absent from our care for a period of two years. The mother states that the child, now 8 years of age, has had the habit of cleansing herself after toilet by wiping from the anal region forward over the external genitalia. When there is a recurrence, the child, on question, will admit that she "forgot and wiped the wrong way." The stools, as well as the vaginal secretions, were teeming with trichomonads which the author was unable to distinguish one from the other. After treatment with vioform powder vaginally, and three 4 gr. vioform tablets\* by mouth daily for one month, all symptoms and signs of the disease have been absent for three months.

Mrs. N. R. has suffered from a vaginal discharge for several years, with occasional attacks of pruritus vulvae and ani. In the fall of 1938 the condition became much worse and she received local therapy by dermatologists for the pruritus. Treatment was continued for six months, when the condition was diagnosed as trichomonas vaginalis vaginitis, and vioform powder insufflations were instituted. The improvement was rapid, and for a period of two months, the patient appeared cured. Then she used a "sanitary pad" during her menses instead of intravaginal tampons as had been her custom. On the second day of her flow there was a return of severe pruritus and, following cessation of the flow, profuse vaginal discharge. The stool and vaginal secretion both contained many motile trichomonads which appeared identical. It is very evident that the vagina was reinfested from the rectum by the pad which was worn. She has subsequently made a complete recovery (four months observation).

Mrs. R. W., complained of frequent loose and very irritating stools, itching around the anus, and a slight vaginal discharge with itching of the vagina. The onset of the loose stools occurred at least thirty-six hours before the vaginal discharge and itching appeared. The vagina presented the typical picture of trichomonas vaginalis vaginitis. The causative organism was demonstrated. The rectum presented a marked inflammatory change with exudate and multiple petechiae. The appear-

\* These tablets are enteric coated with a four hour timing, and produce little gastric disturbance.

ance was very similar to the condition which, in the vagina, has been described as "strawberry vagina." The stool was teeming with trichomonads which were indistinguishable morphologically from the organism found in the vaginal secretion. The patient was given four daily treatments with vioform ointment, and four 4 gr. tablets of vioform daily for ten days. A menstrual period intervened, following which no organisms could be demonstrated in the vagina or rectum. In over two years, there has been no return of symptoms and the trichomonads have not been demonstrated in either the rectum or vagina.

Peterson<sup>8</sup> reports a similar case of acute proctitis due to trichomonas vaginalis complicating acute vaginitis.

A fairly high percentage of women suffering from trichomonas vaginalis vaginitis state that at various times they have had attacks of loose stools, and that subsequently the vaginitis and pruritus were aggravated. Perhaps this is merely a coincidence, but it occurs too frequently, the author feels, not to have some significance.

From the above case reports, there appears to be a very definite connection between the rectal infestation with trichomonas hominis (?) and trichomonas vaginalis vaginitis. In previously reported work on the incidence of these parasites in the intestinal tract, no mention is made of the number of stool examinations done in the individual patient before the presence or absence of the trichomonads in the intestinal tract was demonstrated. It is our firm belief that at least three, and preferably six, separate stool examinations must be made before it can be said that trichomonads are not present in the intestinal tract of a given individual. Failure to make multiple examinations may give an entirely erroneous impression of the incidence. Also, stained smears are technically difficult to prepare and read as compared with a saline suspension of the fresh stool.

It will be interesting to know whether a vaginitis may be produced in the normal vagina, either human or animal, by the

implantation of a culture of trichomonads from the intestinal tract. This would establish, beyond question, the source of infestation of the vaginal tract, and it would seem to establish the postulates of Koch for this disease and organism.

If the postulates of Koch can be proved, a new routine treatment of trichomonas vaginalis vaginitis similar to that being used empirically by the author, should not only prevent most recurrences but also shorten the duration of the disease through elimination of continued reinfestation from the rectum. This should be:

1. Vioform powder insufflations at least three times weekly, as therapy for the vaginitis.
2. Vioform orally in dosage of four 4 gr. tablets daily to eradicate the rectal infestation. The basis for this therapy is the excellent results obtained by David et al.<sup>4</sup> in other parasitic infestations of the intestinal tract.

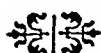
#### SUMMARY

1. A supplementary report of the results of treatment of trichomonas vaginalis vaginitis by means of vioform ointment is given. A total of 106 cases has been treated with 98.1 per cent cured. There were 6.7 per cent recurrences.
2. It was determined by colorimetric methods that the vaginal secretion of trichomonas vaginalis vaginitis is very acid, ranging from pH 4.0 to pH 6.0, as compared to the normal of pH 4.6 to 7.5.
3. A series of 140 cases of trichomonas vaginalis vaginitis were treated by a modification of the ointment technique, using vioform in a powder form. Of these cases 137 have received adequate treatment, and are pronounced cured.
4. Some instances of untoward results from the use of other preparations are reported.
5. A number of cases which tend to substantiate the theory of rectal origin of the disease are reported.
6. A routine of treatment, which the author is now using empirically, is ad-

vanced. This routine is not only directed at the vaginitis, but also is designed to eradicate the organism from the rectum, thereby reducing recurrences to an absolute minimum.

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INJURY or disease of the motor portion of the trigeminal nerve is evidenced by paralysis of the muscles of mastication. The jaw falls open and the acts of swallowing and speech become difficult or impossible. From—"Surgery of Oral and Facial Diseases and Malformations" by George Van Ingen Brown (Lea & Febiger).



# GASTRIC RESECTION\*

## A PLEA FOR THE TWO-STAGE OPERATION

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THE intensive pursuit of clinical research in reference to gastric resection reveals an alarmingly high mortality throughout the world. Statistics show a 15 to 27 per cent mortality in the large clinics, while 47 per cent and more is not uncommon in open hospitals.

Improved methods of clinical investigation and modern methods of diagnosis both favor operation at a much earlier date than practiced in the past. Patients suffering from cancer must be convinced, by all means, that a prompt arrest of the morbid process by surgical operation is the only successful method of treatment. However, the present high death rate, a direct result of the one-stage operation, will by no means encourage patients to submit to early surgical manipulation.

It is therefore obvious that a reduction of the high mortality rate is necessary and that this may be accomplished by eliminating the danger of pulmonary complications so often experienced by us after the one-stage gastric resection, even with the use of local anesthesia.

Billroth is quoted as having said, not long before his death, that the last years of his life and work had been saddened by the large number of almost hopeless cases of cancer which came to his clinic. Describing his experience in cancer of the stomach and the method of operation, he mentioned that few of the patients recovered from the shock. It is true that the most desperate cases, having been given up as hopeless, found their way to Billroth's clinic as the last resort. He quoted his death rate at about 60 per cent.

If operation is carried out in the early stages of the disease, before the patient's

vitality has been unduly impaired, the chances are that mortality will not exceed 10 to 20 per cent. We have therefore returned to the two-stage operation, performing a high gastroenterostomy, and after two or three weeks doing an excision of the ulcerated or cancerous area.

Pauchet and Tierny<sup>1</sup> state that certain patients are not operable immediately on account of their cachectic condition and gastric resection would be extremely dangerous. In such cases gastroenterostomy is performed, and from ten to fifteen days later, when the patients have gained strength and the general conditions permit, gastrectomy follows. They also state further that in gastric ulcer they favor resection, but recommend, in general, a gastroenterostomy which allows the emptying of the stomach.

Pauchet<sup>2</sup> reflects sound surgical opinion in favoring the two-stage gastrectomy in all cancerous or ulcerous cases where the patient is too enfeebled to submit to the one-stage operation. It is advisable to perform a gastroenterostomy necessitating the least possible manipulation. As a rule, an interval of approximately fifteen days is sufficient between the gastroenterostomy and the final gastric resection. The patient will have recovered his resistance sufficiently, and the conditions under which the second operation is performed will be much more favorable. In case of adhesions, they have not become hardened and therefore will not interfere with the procedure. If the tumor to be removed is situated between the anastomosis and duodenum, the surgeon may resect the cancerous segment only, if he can do so successfully without risking further unfavorable results. Pauchet

\* From the Department of Surgery, De Courcy Clinic.

states that he has never lost a patient under these circumstances.

Even in extensive cancerous lesions it appears advisable to perform a high posterior gastroenterostomy, or, if this is not feasible, a high anterior loop anastomosis may be substituted. There seems to be no objection to this method of operation, particularly since we have greatly lowered mortality which compares favorably with other types of abdominal surgery.

It was asserted by Francis Villard<sup>3</sup> in 1893 that most surgeons favored anterior gastroenterostomy, and that the two-stage operation should be chosen. Judging from our own experience, there is no doubt that the two-stage procedure shows final results as satisfactory, if not more so, than with the one-stage method.

We have the report of Smithies<sup>4</sup> in 1916 that patients gain enormously by a properly planned and executed gastroenterostomy, since the patient's life is naturally prolonged and his comfort increased by these changed conditions. He may improve his strength to such a degree that, although the excision of the cancerous growth at the primary operation would undoubtedly have resulted in death from shock, the increase in resistance as a direct result of the improved nutrition and elimination of other disturbing conditions makes a second operation fairly, if not entirely, safe.

This favorable outlook should induce surgeons to select the two-stage plan of operation for the excision of cancer of the pylorus in patients who have been critically reduced by the beginning stages of the disease. Furthermore, it must be stressed that the first stage of the operation should prepare the intra-abdominal conditions in such a way as to be most favorable for the performance of the second stage, to be undertaken at a later date. The latter allows a more careful resection, as there is less need for speed, the patient being in a strengthened condition and thus able to stand the shock even of a prolonged surgical manipulation. Complications such as

pneumonia and pulmonary embolism are absent, as a rule.

It is this favorable condition, created by the improved strength of the patient, which led von Hacker<sup>5</sup> as early as 1895 to consider it of the greatest importance to take recourse to gastroenterostomy as quickly as possible in all such cases which are not fit for direct resection. His own experience showed that more than half of the deaths occurred as a consequence of the loss of vitality in the patients upon whom gastric resection was performed in the first stage operation.

How important it is to select the two-stage procedure in cachectic patients was demonstrated by Bourget<sup>6</sup> in 1902, when he performed a gastroenterostomy upon a man 75 years old. He subsequently left the clinic one week after the second stage gastric resection, though a consultation of three specialists had, from the onset, considered the first operation a futile measure in view of the fact that the patient's strength had been badly impaired. In fact he was almost unable to stand removal to the clinic.

Where the condition of the patient was critical, Bourget was obliged to use the two-stage method quite frequently, even though the cancerous growth of the pylorus might have been removed at once. The second stage was postponed until the strength of the patient permitted it.

Gastroenterostomy should be performed in case of cardiovascular-renal disturbance, diabetes and cachexy, stated Ribas,<sup>7</sup> since this method offers a palliative result where patients with an infected ulcer suffer from autointoxication after prolonged inanition. The second stage operation should be performed at a later date, when conditions appear sufficiently favorable.

The same opinion was expressed by Hoffman<sup>8</sup> in 1911, who considered the two-stage method an excellent one in case of very weak and starved patients. He used this method upon numerous occasions with great and unfailing success. The second operation was undertaken as soon

as the patient had recovered strength as a result of the increased intake of nourishment.

There are several cases cited in which the secondary laparotomy revealed the complete disappearance of an inflamed ulcer, and therefore we may point out that the two-stage method may be of great advantage in doubtful cases.

The two-stage method was also advised by Groves<sup>9</sup> in 1910 in order to diminish the high death rate: a primary gastroenterostomy, and after two weeks a resection. Out of six patients operated upon by this procedure, only one died, and out of eighteen cases cited in literature three deaths occurred.

A factor which speaks most strongly for the method recommended by us is the seriousness of gastric resection even where the surgeon is highly skilled in his technique. At the best, resection takes twice the time or more of gastroenterostomy. I prefer preliminary gastroenterostomy not only as a less dangerous procedure, but also because final results are more satisfactory than they are with immediate resection. Also, with primary resection the chance of a recurrence of the ulcer or cancer is far greater than with gastroenterostomy.

For many years Crile<sup>10</sup> has successfully used the two-stage method on his patients, restoring the metabolic balance by gastroenterostomy. This is followed up by a resection in ten or fourteen days. He claims that this is the only safe method when the patient is seriously weakened by starvation but still operable.

In analyzing success and failure of gastroenterostomy, Roeder<sup>11</sup> in 1921 insisted that, in cases of chronic ulcer which cannot be treated by excision only, gastroenterostomy may be called the most satisfactory procedure. It possesses sufficient merit to recommend a further investigation of its failure—The *bête noire* of gastric surgery—in order to increase successful results.

From his personal experience Wangenstein<sup>12</sup> in 1937 reports that the two-stage operation, obviating retraction of the

esophagus and avoiding contamination, is to be favored.

It is the belief of Schachner,<sup>13</sup> on the other hand, that in the United States the majority of surgeons still favor gastroenterostomy over partial gastrectomy, since the latter, in the hands of surgeons not specially trained, though experienced, has a high mortality. The change to the radical treatment in America has been slower by reason of the outstanding results obtained in the Mayo Clinic, where 8,600 gastroenterostomies have been performed and combined, when necessary, with excision. They claim 90 per cent cure in gastric, and 95 per cent in duodenal ulcers. This result may be called almost perfect.

Charles H. Mayo<sup>14</sup> in 1919 said that in peptic ulcer of the stomach and duodenum gastroenterostomy becomes a mechanical agent in overcoming a biochemic condition, and that the modern treatment by this method is a most satisfactory relief. The early surgical treatment of ulcer by suture anastomosis was used only in cases of acute perforation, obstruction or serious hemorrhage.

Our own extensive experience, together with the aforementioned almost unanimous opinions, induces us to stress more emphatically than ever the importance of a primary gastroenterostomy in cancer of the stomach if the high mortality following an immediate gastric resection is to be reduced.

#### CONCLUSIONS

1. Gastric resection is an excellent operation, but has resulted in excessive mortality.
2. Early and correct diagnosis, determination of indication for operation and improved technique have lowered the high rate of mortality.
3. The favorable outcome of gastric resection depends upon selection of the proper time of operation and a careful method of preparing the patient for gastric resection.

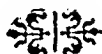
4. Gastric resection, which means a prolonged and serious manipulation, taxing the resistance of the patient to the utmost, should be undertaken only after the condition of the patient has been improved by a primary gastroenterostomy.

5. With the two-stage operation, patients of advanced age, though feeble, have had an excellent chance of recovery and pulmonary complications have been absent.

6. Doubtful cases are benefited by the two-stage procedure.

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# THE SIGNIFICANCE OF STASIS IN ROENTGEN INTERPRETATION OF GALL-BLADDER PATHOLOGY

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EXPERIENCE in x-ray studies of the gall-bladder for the past ten years leads me to believe that the clinical importance of the failure of the gall-bladder to empty or quasi-empty itself after a fatty meal is being minimized. This is particularly true in those cases in which the power of bile concentration in the gall-bladder is of a high degree. I have found that where the gall-bladder retained over 50 per cent of its original iodized contents three hours after a fat meal, however good the concentration might be poor gall-bladder function and potential pathology were present.

This contention, I believe, has been corroborated by gall-bladder visualizations in many cases presenting digestive symptomatology, however slight.

## CASE REPORTS

Mrs. A. K., age 48, on January 9, 1934, complained chiefly of pain in the right upper quadrant, particularly pronounced after eating heavy foods of a fatty nature. At times the pain was referred downward toward the right lower quadrant. She felt full and bloated after meals, but was never jaundiced.

A physical examination revealed nothing of importance except for marked tenderness at the right lower quadrant. A tentative diagnosis of chronic cholecystitis and chronic appendicitis was made. Clinical laboratory studies were not significant.

The first Roentgen study, January 13, 1934, revealed 50 per cent retention three hours after a fatty meal, which consisted of the yolks of two eggs, a glass of milk and cream, half and half, and a few strips of bacon. This study was repeated August 10, 1934 with the same results. During this time medical gall-bladder management was followed fairly rigidly.

On March 1, 1937, reexamination revealed good gall-bladder concentration with 50 per cent retention and a large calculus.

Mr. T. J. C., age 48, on February 14, 1934, complained of "stomach trouble" of sixteen years' duration. He gave a history of bloating and fulness, marked belching, occasional heartburn and nausea.

Physical examination revealed diffuse tenderness throughout the abdomen; but was otherwise negative. A tentative diagnosis of irritable colon was made.

Gall-bladder visualization on February 15, 1934 revealed good gall-bladder concentration with 80 per cent retention, three hours after a fatty meal. The Kahn test was strongly positive and therefore the patient was referred to the syphilologist for antiluetic treatment and was placed on medical gall-bladder management, which he followed for a time. Gall bladder reexamination was done on March 23, 1937, and revealed good gall-bladder concentration with 75 per cent retention, three hours after a fatty meal, and many calculi.

Mrs. J. H., age 48, on April 23, 1934, had as chief complaints headaches, dizziness and urinary incontinence. The headaches were not relieved by headache powders and were worse in the afternoon; the dizziness was constant. There were slight gastrointestinal symptoms, mainly bloating, belching and constipation.

Clinical laboratory studies revealed 10 leucocytes per H.P.F. in the urinary sediment and a moderate lymphocytosis of the blood.

Physical examination was essentially negative. Gall-bladder visualization on April 27, 1934 revealed good concentration and approximately 50 per cent retention three hours after a fatty meal. The patient did not follow the prescribed management and reported for reexamination on November 9, 1935 with complaints accentuated, and in addition, with

pain in the left upper quadrant. Reëxamination of the gall-bladder revealed good concentration; the gall-bladder showed diverticulum and numerous calculi.

Mrs. K. A., age 48, November 18, 1936, had symptoms referable to the menopause and some gastric and cardiac distress. Physical examination revealed generalized abdominal tenderness. An electrocardiogram showed a normal curve. Blood and urine studies were negative. A tentative clinical diagnosis of neurasthenia was made, pending x-ray studies to rule out pathology of the gastrointestinal tract.

Gall-bladder visualization on December 11, 1934 revealed a large dense gall-bladder shadow with approximately 75 per cent retention three hours after a fatty meal.

The patient did not follow the gall-bladder management prescribed and on reëxamination, November 24, 1935, there was a large gall bladder, concentrating well, and filled with calculi.

Mrs. M. D., age 47, reported for examination on September 13, 1935, complaining chiefly of excessive gas in the intestines with marked fulness and bloating after meals, particularly the evening meal; also occasional heartburn. Physical examination and routine laboratory studies were negative.

Gall-bladder visualization November 12, 1935 showed good concentration and 50 per cent retention three hours after a fatty meal. This patient did not follow the prescribed gall-bladder regime and reported again on November 16, 1936 with the same complaints. Reëxamination of the gall-bladder then showed good concentration and two large calculi.

Mrs. E. H., age 48, on June 20, 1926, complained of shortness of breath accompanied by symptoms usually attributable to gall-bladder disease. Physical examination and clinical laboratory studies were essentially negative.

The first gall-bladder visualization, September 15, 1936, showed good gall-bladder concentration and 75 per cent retention three hours after the fatty meal. The patient did not follow the prescribed treatment and on reëxamination, February 15, 1937, the gall-bladder was found concentrating well, retaining over 50 per cent of its original contents three hours after a fatty meal, and filled with calculi.

It has been established that the lymphatics and blood supply of the gall-

bladder are mostly responsible for the power of bile concentration in the gall-bladder. The main network of lymph channels is in the subserous layer of the gall-bladder wall and the dense muscular wall is almost without lymphatic vessels. It is easily seen, therefore, that so long as this network is free from pathologic involvement, the power of bile concentration in the gall-bladder is not greatly disturbed, even though the process is so extensive as to minimize or eliminate the contractibility of the gall-bladder wall. Thus in Roentgen studies, one is not justified to assume normality because of good roentgenologic gall-bladder density.

Chemical analyses made during the early experimental work on cholecystography showed that the average concentration of halogen per unit volume of bile in gall-bladders which cast shadows of maximum density, was several times that of the bile which was not allowed to enter the gall-bladder. In other words, it seems that radiographic density, depending as it does on the power of gall-bladder concentration, is contingent on whether or not the pathology is of an intrinsic or an extrinsic nature; on whether or not the subserous zone of the gall-bladder wall is involved.

It appears that the elasticity of the gall-bladder is an important factor in its emptying and refilling. It is apparently independent of active concentration but dependent upon the large amount of elastic tissue in the fibromuscular coat, which in most cases of intrinsic pathology is either damaged or greatly increased. Indeed in advanced cases of intrinsic pathology, the fibromuscular layer loses altogether its distensibility and power of contractility.

If clinical and radiographic results are a guide, I would say that there is evidence that a slightly diseased gall-bladder or one with diminished function may become practically normal under proper management. This we have observed in scores of cases.

That gall-bladder disease may start intrinsically was shown by Rosenow who, in many instances, obtained bacterial cultures from the gall-bladder mucosa, even in the presence of sterile bile.

It has been stated that biliary stasis is most pronounced in the visceroptotic type of individual in whom gall-bladder disease is less frequent. I wonder if such conclusions were based on roentgenologic observations made three hours after the ingestion of a fatty meal. A retention of more than 50 per cent after this time has definite pathologic significance. Three of the cases reported were women of the visceroptotic type.

Biliary stasis may therefore be a factor in cholecystitis, as Seelig considered. Aschoff and Bacmeister, at a time when radiographic help was not available, called attention to its importance in the formation of biliary calculi. The experimental biliary calculi produced by Whitaker in animals were the result of obstacles to the normal mechanism of emptying and filling of the gall-bladder.

The two main theories of the formation of gallstones, namely, stasis and infection, are in reality only one. Infection will lead to pathologic changes in the gall-bladder wall which will ultimately lead to stasis. All other theories are based on bile concentration in the gall-bladder which is obviously the result of stasis. Lichtwitz's theory expounds the belief that bile is a colloid held in suspension by ions with negative charges; once the stasis has made for an acid reaction of the bile, there is a disturbance in the suspension of cholesterol ions with a resultant precipitation. Findley considers that the formation of gallstones is a result of a reduction in the amount of

protective colloids in the bile, brought about by abnormal conditions (stasis?).

I believe, therefore, that a roentgenologic study of the gall-bladder in cases of good concentration is incomplete unless studies are made three hours after a fatty meal. Where there is a residue of 50 per cent or more, the case should be labeled as having poor gall-bladder function and regarded as potentially pathologic. Even though the gall-bladder wall may be invaded with lymphocytes and plasma cells and the fibromuscular layer has been altered, good radiographic density may still be obtained, provided the vascular and lymphatic mechanisms have not been disturbed.

#### CONCLUSIONS

1. Good gall-bladder concentration as shown by hyperdense Roentgen shadows does not eliminate gall-bladder pathology unless the shadow disappears or almost disappears three hours after the administration of a fat meal.
2. The so-called strawberry gall-bladder is a good example of intrinsic gall-bladder pathology. As a rule x-ray studies in these cases give hyperdense gall-bladder shadows.
3. Gall-bladders retaining over 50 per cent after a fat meal, if symptoms persist in spite of proper medical management, clearly belong in the surgical field.

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# CASE REPORTS

## THE CLINICAL ASPECTS OF ARTERIOVENOUS FISTULAE\*

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WITH the possible exception of the glomus, arterial blood must, under normal conditions, pass through a capillary bed before entering the venous circulation.<sup>35</sup> The abnormal shunting of blood directly from the arterial to the venous system produces an interesting group of changes which are evident not only at the site of the primary pathology but are also manifested in certain central or systemic effects. A variety of clinical terms are used to describe such an abnormal communication,<sup>17</sup> indicating the variegated clinical appearance of these lesions.

We present herewith a group of six cases of arteriovenous fistula which have been observed in conjunction with the Peripheral Vascular Clinic of the Shreveport Charity Hospital. The studies of these more or less typical cases were purely clinical. The cases consist of one congenital arteriovenous aneurysm and five acquired fistulae, four of the acquired being in the extremities and one located intracranially.

The changes produced by an abnormal arteriovenous communication are (1) local, (2) peripheral, and (3) systemic.

*Local Effects.* The local manifestations of an arteriovenous fistula are frequently typical enough to be pathognomonic providing the lesion is superficially located. The pulsating tumor with characteristic continuous thrill and bruit and systolic accentuations is too well known to need description.<sup>41</sup>

*Peripheral Effects.* Peripheral effects from an arteriovenous aneurysm are characteristically noticeable when the lesion involves the vessels of an extremity. The chief factor in the production of these peripheral effects is venostasis due to blockage of the normal venous return. The edema, the pigmentation, the ulcerations and varicosities which may be noted are largely the result of this interference with the normal venous circulation from the shunting of a portion of the arterial blood directly into the venous channels. In congenital arteriovenous fistulae of an extremity, the stasis may cause, by the delayed removal of nutritious material, a unilateral hypertrophy of the involved extremity.<sup>16,21,38</sup>

*Systemic Effects.* While the central or systemic effects of an arteriovenous fistula are perhaps the most significant and important results of such a lesion, this subject has so frequently and thoroughly been presented by numerous authors that it needs no lengthy discussion at this time.<sup>2,5,7,9,12,13,14,18,23,25,26,30,31,32</sup> It is because of these systemic effects that arteriovenous aneurysms are potentially such serious lesions, although, of course, all such lesions do not necessarily produce cardiac damage. In summary, it might be recalled that arteriovenous fistulae, especially the larger and more centrally located ones, are prone, due to the extra work thrown upon the heart, to produce cardiac decompensa-

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tion; that this is more likely to occur in older individuals with preëxistent cardiovascular disease, but that it may occur in (0.67 per cent) were unquestionably congenital. McNealy<sup>29</sup> found one case in his series of twenty-seven (3.7 per cent).



FIG. 1. Case 1. Congenital arteriovenous aneurysm. Note the pigmentation and engorgement of the superficial veins. Note also greater length of the right leg as compared to the left.

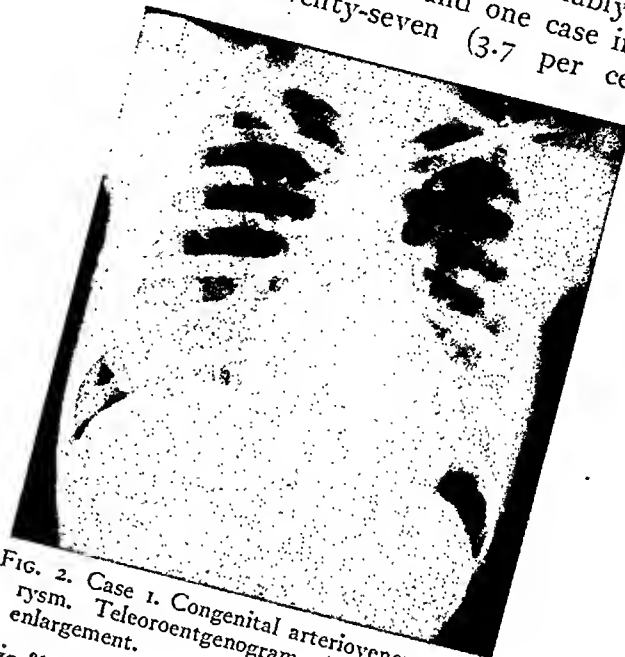


FIG. 2. Case 1. Congenital arteriovenous aneurysm. Teleoroentgenogram showing cardiac enlargement.

any instance; that at times these lesions are surprisingly well tolerated, and if corrected before too extensive cardiac damage has been done, complete recovery may ensue.

Arteriovenous fistulae may be either congenital or acquired. The acquired variety most frequently results from trauma, usually a penetrating or transfixing wound, such as that caused by a bullet or dagger, particularly when occurring at those situations where artery and vein are fixed in a common sheath in an exposed, unprotected place such as Scarpa's triangle, popliteal space, axilla, cubital space and neck. Congenital arteriovenous aneurysms are, clinically at least, surprisingly infrequent. Callander<sup>4</sup> collected 447 cases of arteriovenous aneurysm of which only three

Lewis,<sup>21</sup> in 1930, added four cases of his own to a series of twenty-four collected from the literature, a total of twenty-eight cases. Horton,<sup>16</sup> in 1932, reported twenty-four cases observed at the Mayo Clinic during a two-year period. Veal and McCord<sup>38</sup> were able to collect seven cases at the New Orleans Charity Hospital in a period of one year, and indicated that from a cursory review of the literature, something more than 100 cases in all have been recorded. In this present series of six arteriovenous aneurysms one (16.6 per cent) was congenital in type.

**Clinical Diagnosis.** The detection of an arteriovenous fistula is frequently a simple matter, particularly in the larger and more superficially located lesions. In the traumatic variety, the history of a characteristic trauma is frequently obtained and is of great value in pointing to the correct diagnosis. The presence of an otherwise unexplained unilateral hypertrophy of an extremity is extremely suggestive of a congenital arteriovenous communication. The clinical points in diagnosis may be grouped similarly to the manifestations of

these lesions, viz.: (1) local, (2) peripheral, and (3) systemic.

*Locally*, we find in a typical case, the pulsating tumor with characteristic bruit and thrill. If present, these local manifestations are frequently sufficient evidence upon which to base a diagnosis. *Peripherally*, we find the evidence of admixture of arterial and venous blood with venous stasis. The pigmentation, edema, and ulcerations which may be present, are indistinguishable from those seen in ordinary varicosities. The veins may be visibly distended and frequently there is an elevation of venous tension and increased oxygen content of the venous blood. Usually there is little evidence of interference with arterial circulation, despite the shunting of a portion of its current into the venous channels. *Systemically*, there may be noted cardiac decompensation in the more advanced lesions, but the phenomenon which is rather characteristic of an arteriovenous fistula is the so-called Nicoladoni-Israel-Branham bradycardiac phenomenon. It was first noted by Nicoladoni in 1875 and by Israel in 1877, though it is usually attributed to Branham, who reported it in 1890.<sup>36</sup> Certain characteristic changes in pulse and blood pressure are noted upon direct digital closure of the fistula. The usually described alterations produced immediately upon occluding the fistula are: (a) a slowing of the pulse; (b) an increase in diastolic pressure; and (c) an increase in systolic pressure.<sup>6,25</sup> The fact that these changes can be produced by compression of the fistula is an index of the significant systemic effects that may be produced by such a lesion.

Arteriography<sup>38</sup> is frequently of confirmatory value. By this method, the lesion may be visualized and the rapid shunting of arterial blood into the venous circulation detected.

*Treatment.* Whenever amenable to therapy, these lesions should be corrected as soon as possible to prevent cardiac damage, which is a possibility in many instances. Ideally, such treatment consists of a repair

of the fistulous opening. In other instances it is necessary to extirpate the lesion, first "training" the collaterals to prevent, if



FIG. 3. Case 11. Traumatic arteriovenous aneurysm of right popliteal vessels. The increased size of the right leg, the pigmentation, dilated veins and ulcerations are apparent.

possible, distal trophic changes such as gangrene. At times an extremity has to be amputated either from gangrene resulting from interference with arterial circulation, or because of disability resulting from the peripheral (venous) effects of such a lesion. Other methods, such as injection of the venous system with obliterating drugs, etc., are of doubtful value other than affording temporary relief from severe varicosities.

#### CASE REPORTS

The following illustrative cases are presented in summary form, emphasis being placed only on those points which lead to the diagnosis made in each case, with notes on the treatment and progress of each.

**CASE 1.** A white female, aged 18 years, was admitted February 13, 1936. The final diagnosis was congenital arteriovenous aneurysm of the right lower extremity.

**Diagnostic Points.** Significant Points in History. Since childhood the patient had noticed that her right lower extremity was not noted over the right popliteal artery and there was no bruit over any of the corresponding vessels of the left lower extremity. Maximal

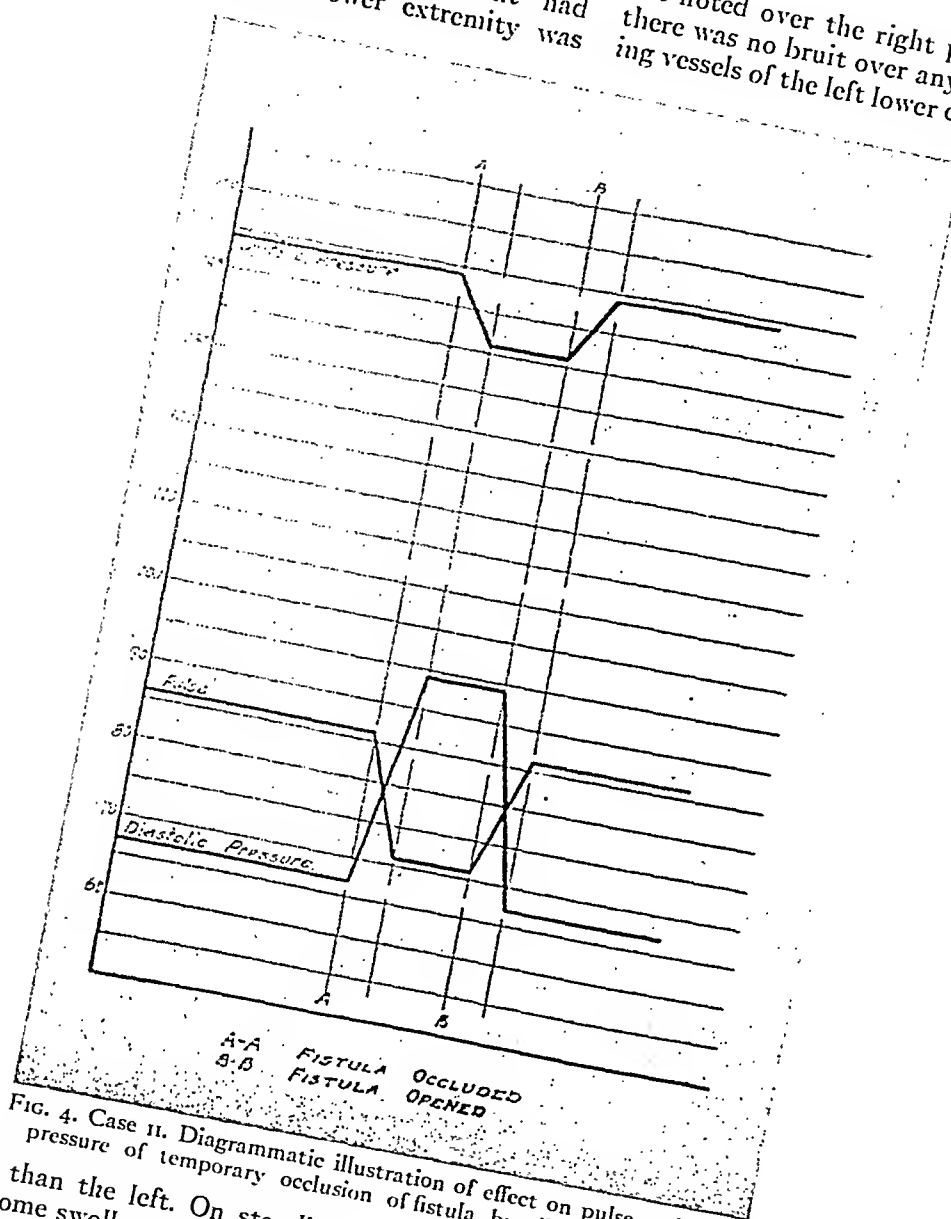


FIG. 4. Case 11. Diagrammatic illustration of effect on pulse and blood pressure of temporary occlusion of fistula by digital compression.

somewhat longer than the left. On standing, the leg would become swollen and edematous. Ulcerations on the anterior aspect of the lower third of the right leg had occurred for several summers, healing in the winter. No ulcers were present at time of admission.

**Local Manifestations.** No localized tumor or lesion was present. All pulses in the right lower extremity were full (graded 4 to 4 plus). There was a systolic thrill on palpation of the right femoral artery, and auscultation over the right femoral, posterior tibial and dorsalis pedis revealed a soft systolic bruit. This bruit was

oscillometric phase (MOP) of the mid-third of the left leg was 2 units between 110 to 100 mm. mercury pressure. MOP for the mid-third of the right leg was 12 units between 100 to 70 mm. mercury pressure.

**Peripheral Manifestations.** Brownish pigmentation was noted on the entire right lower extremity, more marked on the leg and foot. (Fig. 1.) There was moderate edema of the right ankle, but the left lower extremity was entirely normal. From the right anterior superior iliac spine to the tip of the corresponding internal malleolus was a distance of 38 inches

(95 cm.) as compared to 36.25 inches (90.6 cm.) on the opposite side. No appreciable differences were apparent in circumference of the two lower

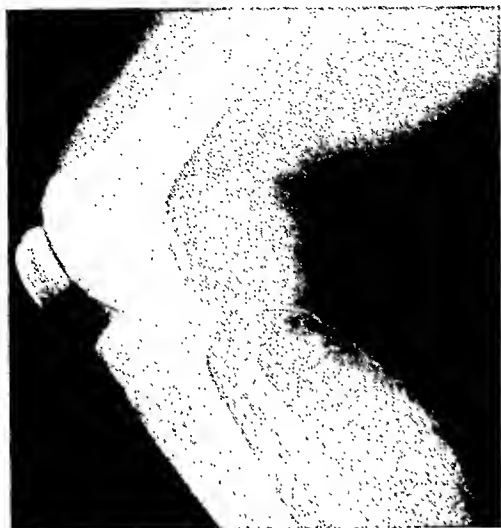


FIG. 5. Case II. Arteriogram in case of arteriovenous aneurysm between popliteal vessels. Note visualized aneurysmal sac, tibial vessels and femoral vein.

extremities. Venous pressure at the right ankle was 19 cm. of water. The average temperature of the right lower extremity was 33.8°C., as compared to 31.5°C. for the left lower extremity.

*Systemic Manifestations.* The blood pressures were as follows:

Right arm: 140/80	Left arm: 136/70
Right leg: 152/100	Left leg: 144/100

A cardiologic consultant reported the presence of cardiac hypertrophy and that the "tracing while not decidedly abnormal, is suggestive of myocardial disease." X-ray of the heart revealed a heart shadow enlarged in its transverse diameter. (Fig. 2.)

*Comment.* A clinical diagnosis of congenital arteriovenous aneurysm was believed to be justified in this case. The clinical factors pointing to this diagnosis were: (1) unilateral hypertrophy of the right lower extremity, present from childhood, and otherwise unexplained; (2) pigmentation, edema and other evidences of chronic venostasis in the right lower extremity; and (3) evidences of cardiac dilatation and hypertrophy, otherwise unexplained. As is so frequently observed in congenital lesions, the exact location of the fistula or fistulae was not evident from clinical examination. The thrill and bruit detected over the vessels of the right lower extremity were confirmatory evidences of the presence of such a vascular anomaly.

This patient showed little change in her condition during hospitalization. It was thought probable that the fistula involved the pelvic



FIG. 6. Case III. Traumatic arteriovenous aneurysm left axillary vessels, aortic insufficiency. Teleroentgenogram showing marked cardiac enlargement.

vessels. We considered exploratory laparotomy to determine the exact site of fistula and whether or not it would be amenable to surgery, but this was refused by the patient. The patient was discharged from the hospital in an unimproved condition and with an unfavorable prognosis.

**CASE II.** White male, aged 24 years, admitted January 10, 1936; in this case the final diagnosis was traumatic arteriovenous aneurysm between the right popliteal artery and vein, with trophic ulcerations right leg.

*Diagnostic Points. Important Points in History.* Three years previous the patient was shot with a pistol (38 "Special"), the bullet passing through the right popliteal space. After recovering from the immediate effects of the wound, he was free of any symptoms until about five months prior to admission. At that time he noticed a pulsating mass in the right popliteal space and engorgement of the superficial veins in the right leg and pain was constant. For a month an ulceration had been developing on the right leg.

*Local Manifestations.* In the right popliteal space there was an ovoid tumor, pulsatile, and with a definite continuous thrill and bruit, both with systolic accentuations.

*Peripheral Manifestations.* That there was moderate interference with normal arterial flow in the right lower extremity was indicated by the



FIG. 7. Case IV. Traumatic arteriovenous aneurysm between popliteal vessels. Note the pigmentation and ulcerations due to venostasis.

2. Venous pressure in the upper part of the left leg was 8 mm. of mercury as compared to a pressure in the veins of the upper part of the right leg of 18 mm. of mercury.

3. There was a dusky red color of the lower third of the right leg, with a small varicose ulcer 2 by 3 cm., located 7 cm. above the tip of the external malleolus. The presence of colateralization in the right leg was indicated by an average temperature of the right leg of 31.4°C., compared with an average temperature of the left leg of 30.7°C., both readings being obtained at constant blood (mouth) and room temperatures.

*Systemic Manifestations.* The blood pressure was 146/76 in the right arm, 144/70 in the left arm, and 178/110 in the left leg.

Before digital occlusion of the fistula the pulse in the right radial was 88 per minute; immediately on occlusion it slowed to 72 per minute (Branham's phenomenon). Before occlusion blood pressure in the right arm was 144/68; after occlusion it became 136/94. (Fig. 4.)

*Cardiologic survey,* including x-ray, revealed no evidence of cardiac enlargement or decompensation.

*Comment.* The diagnosis of arteriovenous aneurysm between the right popliteal vessels presented little difficulty. There were: (1) the characteristic local findings at the site of the lesion; (2) the presence of venostasis and an elevation of venous pressure; and (3) the Branham phenomenon. Although there were no clinical evidences of cardiac damage, surgical repair was advised, not only because of the disabling local and peripheral effects of the lesion, but because of the potential damage to the heart. However, the patient refused surgery and left the hospital. Approximately one year later (December 31, 1936) he returned to the hospital with the history of increasing pain in his right leg and the occurrence of new ulcerations. There had been no dyspnea, no dependent edema, chest pains or any other symptoms referable to the central circulatory system. Two weeks prior to admission a spontaneous venous hemorrhage had occurred from one of the ulcers, causing the loss of considerable blood.

Reëxamination revealed few local changes. The aneurysm had remained approximately the same size and the characteristic bruit and thrill were present. *Peripherally,* there was more

fact that both the right posterior tibial and the dorsalis pedis arteries were less palpable than the corresponding ones in the left leg. Furthermore, the maximal oscillometric phase (MOP) in the mid-third of the right leg was 6 units compared to a maximal oscillometric phase (MOP) in the mid-third of the left leg of 7 units between pressures of 90 and 60 mm. mercury. Interference with arterial circulation in the right popliteal space was further indicated by MOP in the right thigh of 11 units at 90 mm. mercury pressure compared to MOP in the left thigh of 3.5 units between 90 and 80 mm. mercury pressure.

Numerous evidences of interference with normal venous circulation in the right leg, below the popliteal space, were present. These were:

1. Dilated, non-pulsating, veins on the posterolateral aspect of the upper half of the right leg, very pronounced on standing, less marked in the recumbent posture. The veins in the left leg were visible, but not nearly so distensible.

marked evidence of interference with normal venous circulation in the right leg. This leg was larger, more dusky in appearance and three ulcerations were now present. (Fig. 3.) The veins were more distended and the venous pressure (patient recumbent) at the mid-third of the right leg was 32 mm. of mercury as compared to a venous pressure in the mid-third of the left leg of 7.25 mm. of mercury. Pressure over the aneurysmal site elevated the venous pressure in the right leg to 40.5 mm. of mercury, but did not affect the left side. Systemically, little change was noted in the cardiac size or function. The blood pressures were found to be: 150/76 in the right arm; 152/78 in the left arm; and 204/104 in the left leg. The following effects were noted on occlusion of the fistula by digital compression (observations made in left upper extremity): pulse 90 per minute, blood pressure 150/64 before compression. Immediately on occluding fistula, the pulse became 80 per minute and blood pressure 142/70. On release of compression, values returned to previous levels.

An arteriogram was done following the injection of 12 c.c. of thorotrast into the right femoral artery. (Fig. 5.) This revealed a femoral artery about normal in size; the femoral vein was greatly dilated, filling almost simultaneously with the artery. Only a minimal number of muscular branches were visualized. The sacular popliteal aneurysm was visualized, with its apparent arterial and venous connections. Most of the vessels in region of the knee were either branches from the aneurysmal sac or intimately connected with it.

Thus, after an elapse of approximately one year between two examinations of a patient with arteriovenous fistula between the right popliteal vessels, there was little evidence of serious central circulatory effects. There was, perhaps a little lowering of diastolic pressure and an elevation of the systolic pressure, but few cardiac effects had resulted. Peripherally, however, there were decidedly more marked evidences resulting from the increasing interference with normal venous circulation.

This time the patient consented to surgery, largely because of the peripheral disabling effects of the lesion. Following a period of intermittent compression of the fistula to "train" the collaterals, the fistula was excised. There was little postoperative difficulty and the patient made a rapid recovery, the ulcerations

completely healing before discharge from the hospital.

**CASE III.** A colored male, aged 33 years, admitted March 16, 1935, was finally diagnosed as a case of the traumatic arteriovenous aneurysm between left axillary vessels, with aortic insufficiency and cardiac decompensation.

**Diagnostic Points. Significant Points in History.** Five years before admission (1930) the patient received a deep cut in his left axilla which bled profusely and required suturing. About seven to ten days later he noticed a pulsation in this region which had persisted unchanged to the time of examination. About one month prior admission he had an attack of influenza and this apparently precipitated a moderate degree of cardiac decompensation, dyspnea on exertion and swelling of the ankles. He had never previously had any symptoms suggestive of decompensation. With rest in bed, the symptoms of decompensation had improved.

**Local Manifestations.** Underneath the scar in the left axilla was found a pulsating mass with continuous thrill and bruit, both having systolic accentuations. Pressure over the second part of the subclavian obliterated the pulsation, thrill, bruit, and left radial pulse, the patient tolerating this compression with no discomfort for several minutes.

**Peripheral Manifestations.** Enlarged pulsating veins were found on the anterior aspect of the upper left arm. The venous pressure in the right median cubital vein was 85 mm. of water, that in the left median cubital vein 180 mm. of water. Reverse flow in the superficial veins of the left arm was demonstrable.

**Systemic Manifestations.** Branham's phenomenon could not be elicited. The blood pressure was found to be 160/0 in the right arm, 154/32 in the left arm, 250/0 in the right leg and 260/0 in the left leg.

Cardiologic survey (M. D. Hargrove) resulted in the following conclusions:

"1. Syphilitic heart disease and arteriovenous aneurysm.

"2. Hypertrophy, aortic regurgitation, arteriovenous aneurysm, left axillary artery and vein.

"3. Congestive failure.

"4. EKG reveals left axis deviation with definite evidence of myocardial damage.

"5. Class III.



MAY, 1939

"Note: Entire picture may be due to arteriovenous aneurysm and certainly it is the major element at the present time."

axillary scar a pulsating mass having characteristic thrill and bruit. The veins beyond the fistula were dilated, pulsatile and under in-

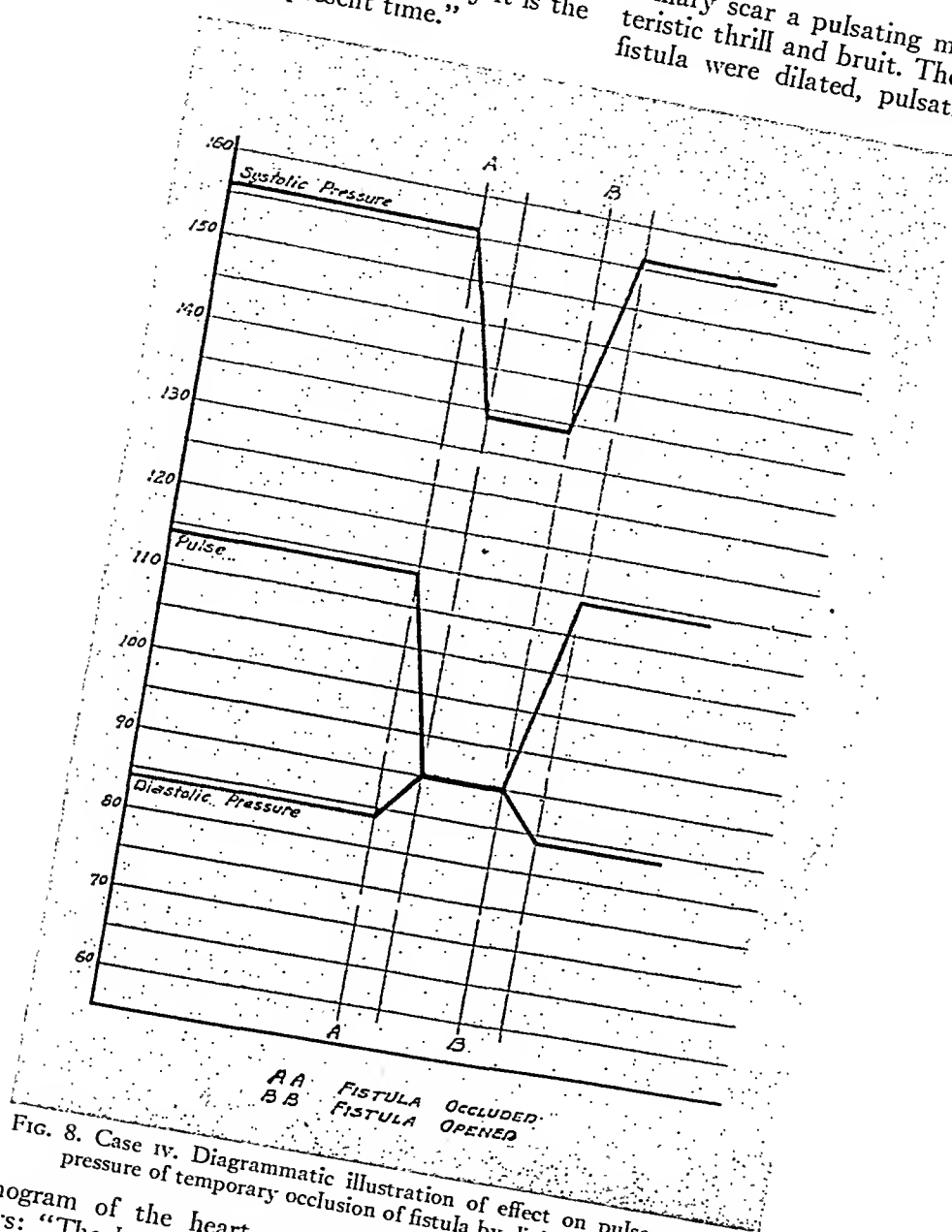


FIG. 8. Case iv. Diagrammatic illustration of effect on pulse and blood pressure of temporary occlusion of fistula by digital compression.

Teleoroentgenogram of the heart was reported as follows: "The heart shadow shows 25 to 30 per cent uniform enlargement." (Fig. 6.)

Comment. The diagnosis of traumatic arteriovenous fistula was rather evident. Here we had a history of a typical injury; a penetrating wound with a sharp instrument in the course of large vessels in a relatively unprotected location, followed by a profuse hemorrhage. There was present beneath this

creased tension. Systemically, marked cardiac decompensation was evident. In this instance, however, there was probably an associated luetic aortic lesion (insufficiency) which facilitated the development of cardiac decompensation. Operative intervention was refused by the patient and he died a cardiac death approximately four months after this examination.

CASE IV. A white male, aged 60 years, was admitted February 25, 1936. Traumatic arteriovenous aneurysm of the left popliteal

vessels, with trophic ulcers of left leg and arteriosclerosis, was diagnosed.

*Essential Points in History.* Thirty years before the patient was shot with birdshot in the region of the left popliteal space. A few days thereafter he became conscious of a pulsation in that area which had been present ever since. His only disability had been due to ulcerations on the left leg in the region of the ankle. These ulcers first appeared fifteen years previous and had been present off and on ever since. The present ulcer had been noted for one and one-half months. In the past, injection of varicose veins and removal of segments had been attempted and had caused temporary healing of the ulcers. There had been no dyspnea, ankle edema, or other symptoms suggestive of cardiac decompensation.

*Inspection.* Slight brawny edema was seen in the region of the left ankle. A brownish-purple area of discoloration measuring 12.5 by 16.25 cm. was located over the lower third of the left leg on its posterior and medial aspects. Just above the internal malleolus, and at about the mid-portion of the area of discoloration, was an oval, punched-out ulcer with a diameter of 2.5 cm., having a clean base. Immediately adjacent to the ulcer and just below and posterior to it was a smaller encrusted ulcer with a diameter of 0.6 cm. (Fig. 7.)

*Pulses.* Both femorals and dorsalis pedalis arteries were palpable, graded 4. The right popliteal was graded 4, the right posterior tibial graded 3. Both radials were palpably sclerotic, graded 3. We were unable to palpate the left dorsal pedis because of the brawny edema. Palpation over the left popliteal fossa revealed a distinct thrill with systolic accentuation.

*Arterial Pressures.* Right arm: 130/70; left arm: 140/74; right leg: 200/100. On taking the blood pressure in the left leg, with the cuff just above the popliteal space and auscultating over aneurysm, we noted that the first sound was heard at 190 mm. of mercury pressure, and that this sound had normal qualities. At 160 mm. pressure it first began to take on the characteristics of a bruit, which increased in intensity and duration until at a pressure of 90 mm. there was a continuous bruit with systolic accentuation.

*Venous Pressures.* The vein at the inner aspect of the right ankle showed a pressure of 52 mm. water, that at the inner aspect of the left ankle, 280 mm. water.

*Oscillometry.* MOP at the lower third of the right thigh was 1.5 units between pressures 110 and 80 mm. mercury; left thigh, 12 plus

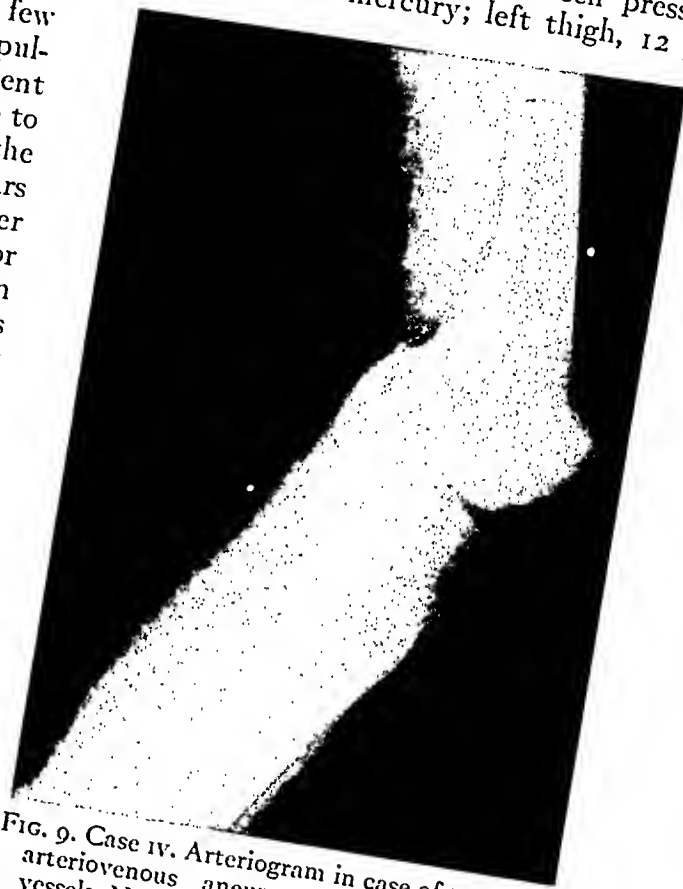


FIG. 9. Case IV. Arteriogram in case of traumatic arteriovenous aneurysm between popliteal vessels. Note that veins and arteries are simultaneously filled.

units between pressures 120 and 100 mm. mercury; MOP mid-third of the right leg, 5 units between pressures 110 and 90 mm. mercury. MOP mid-third of the left leg, 4 units between pressures 110 to 90 mm.

*Dermal Thermometry.* The average temperature of the left leg and foot was 31.75°C.; that of the right leg and foot, 29.8°C.; the right lower thigh and popliteal space, 31.4°C.; and the left lower thigh and popliteal space, 31.75°C.

*Effect of Digital Compression of Fistula.* Before occlusion, the pulse rate was 114 per minute, and the blood pressure 156/84. Immediately on occlusion of the fistula, the pulse rate dropped to 90 per minute and the blood pressure became 134/90. Upon release of compression, values approached previous levels. (Fig. 8.)

*Arteriogram.* Twelve c.c. of thorotrast was injected into the left femoral artery at the base of Scarpa's triangle. There was noted a moder-

ate calcification of the anterior and posterior tibial arteries. The femoral vein filled almost simultaneously with the arterial system. The aneurysm was revealed as a fairly small sac; the anterior and posterior tibials were well filled, with a minimal visualization of collaterals. (Fig. 9.)

**Cardiac Examination** (M. D. Hargrove) resulted in the following report:

- "1. The EKG shows no definite evidence of myocardial disease, sinus rhythm with occasional premature beat.
- "2. The teleoroentgenogram reveals no appreciable cardiac enlargement.
- "While there is no cardiac hypertrophy, and no perceptible dyspnea or cardiac complaint, it is evident that the arteriovenous aneurysm is having some deleterious effect upon the heart. This is manifested by the elevated pulse (95) and delayed response to exercise. This process having been in progress for thirty years, it is evidently slow in advancing, but should his evident arteriosclerosis increase or the heart be subjected to any additional strain, the progress would probably be rather rapid."

**Summary of Diagnostic Points.**

1. History of penetrating wound in left popliteal space in region of large vessels in a relatively unprotected location.

2. Small pulsating mass in left popliteal fossa, having characteristic thrill and bruit.
3. Arterial manifestations: Blood pressure 140/74. Ample flow of blood through main arterial channels as indicated by oscillograms, arteriogram, absence of superficial evidence of arterial blockage.

4. Venous manifestations:

- (a) Visibly engorged superficial veins of left leg.
- (b) Venous pressure 280 mm. water on left side as compared to 52 mm. water on right leg.
- (c) Varicose pigmentation, edema, ulceration.

5. Branham's bradycardiac phenomenon.
6. Arteriogram.

**Comment.** This case was interesting from several points. In the first place, although the lesion had existed for some thirty years and there was associated a moderate degree of arteriosclerosis, there had resulted no appreciable systemic ill effects. The main disability was the result of stasis in the superficial venous system of the left leg. On several previous occasions the underlying pathology had apparently

been overlooked and attempts made to correct the condition by local treatment of the varicosities. Such treatment was ineffectual and improvement was merely temporary. The patient refused surgery and left the hospital in an unimproved condition, although some relief was afforded by the use of an elastic bandage. There was no reason to expect any severe systemic ill effects after so many years, although no real improvement was considered possible unless the fistula were repaired.

**CASE V.** A colored male, aged 26 years, admitted September 24, 1936, had an arteriovenous aneurysm of the right subclavian vessels, with gangrene of the right hand.

**Diagnostic Points. Important Points in History.** Sixteen days prior to admission the patient had received a bullet wound in the region of the right subclavian vessels. There was immediate evidence of injury, and gradually since the injury there had developed a "dry" gangrene of the right hand while the right arm and forearm had remained edematous and slightly discolored.

Locally there was, beneath a healed bullet wound one-half inch below the mid-third of the right clavicle, a palpable continuous thrill with systolic accentuation. On auscultation there was heard a continuous to and fro bruit with systolic accentuation. Peripherally, the right upper extremity was edematous, averaging 2 to 6 cm. larger than the left upper extremity in diameter. Evident gangrene was present in the right hand. (Fig. 10.)

Systemically, the blood pressure (left arm) was 120/80. Branham's phenomenon could not be elicited. The result of a teleoroentgenogram was reported as "heart maximum transverse diameter 15 cm. Aorta 6.5 cm."

**Comment.** Based mainly on local findings, a diagnosis of arteriovenous fistula between the right subclavian vessels and its removal was deemed necessary. The arm was elevated with an overhead sling to reduce the edema and periodic compression of the fistula to "train" the collaterals was done. The patient was given twelve hours of passive vascular exercise (80 mm. mercury pressure, 40 mm. mercury suction, Landis-Gibbon type of curve). The extremity was apparently benefited to the extent that it became warmer (collateralization) and more sensation was present. After

five days of preparation amputation in the lower third of the forearm was done; healing occurred by primary intention. Further com-

and left temporal region. Pressure over the left common carotid caused obliteration of the head noise, pulsation and bruit.



FIG. 10. Case v. Traumatic arteriovenous aneurysm between right subclavian vessels. Note edema, discoloration of hand and excoriation, indicating gangrenous condition.

pression of the fistula to "train" the collaterals was carried out; three weeks after amputation exploration was done, and an arteriovenous communication found as anticipated. Obliterative aneurysmorrhaphy was done, and the patient had an uneventful recovery.

**CASE VI.** This case has previously been reported in detail<sup>10</sup> because of certain interesting features it presented. Therefore it is merely presented in summary form as an example of an intracranial arteriovenous aneurysm. A traumatic arteriovenous aneurysm between the left cavernous sinus and the internal carotid artery; with primary left optic atrophy, occurred in a white male, aged 27 years, admitted October 7, 1931.

**Diagnostic Points.** There was a history that two months previously an aeroplane crash had rendered the patient unconscious and caused a fracture of the base of the skull. Upon regaining consciousness three days after the accident, he was aware of a pulsating roar in his head, synchronous with the heart beat. Several weeks later, the initial edema having subsided, the left eye became swollen, reddened, and began to bulge; vision in this eye had gradually failed. Both eyes had gradually rotated inward.

Examination revealed pulsating exophthalmos of the left eye, bilateral abducens palsy and primary optic atrophy of the left optic nerve. There was a continuous bruit, with systolic accentuation, heard over the left eye

**Comment.** Following a period of intermittent compression of the common carotid, to "train" the collaterals, ligation of the left external and common carotid arteries and left internal jugular veins was done. Recurrence occurred, probably because of an anomalous ascending pharyngeal artery; attempts further to obliterate this vessel were only partially successful. Several months after discharge from the hospital, in a partially improved condition, the patient was lifting and straining to dislodge a bogged automobile with the result that there was a sudden complete disappearance of the noise. Evidently the straining had increased intravenous pressure and jammed shut a flap between the arterial and venous systems. At the present time, some six years after the disappearance of the noise, there has been no evidence, either subjective or objective, of a persistency of the arteriovenous fistula. The eye has receded and the abducens palsy has disappeared, although there has been no improvement in the eye with the optic atrophy.

#### SUMMARY AND CONCLUSIONS

1. Six cases of arteriovenous aneurysm are reported, illustrating the local, peripheral and systemic effects of such lesions.
2. In most instances of arteriovenous aneurysm, particularly the traumatic type, the diagnosis is readily made from the local findings at the site of the lesion.

3. Most of the peripheral effects noted are the result of interference with normal venous circulation.
4. The dangers of central circulatory damage from an arteriovenous aneurysm are real. Such damage is particularly likely to occur in the larger, more centrally located lesions, but the possible cardiac damage that may result from any such lesion makes its correction imperative wherever practical.

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# ACQUIRED INTERFASCIAL BURSA COMPLICATING WANGENSTEEN REPAIR FOR VENTRAL HERNIA\*

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IN 1934, Wangenstein<sup>1</sup> described the use of pedicle flaps of iliotibial fascia for the repair of difficult ventral and inguinal herniae. The method has been used at the Hospital for the Ruptured and Crippled in several selected cases and in one of these the end result was complicated by the development of a bursa between the fascial flap and the anterior rectus sheaths. The case is described below.

A. B., female, age 43, was admitted to the Hospital for the Ruptured and Crippled on March 19, 1937. Her history disclosed a pelvic laparotomy through a midline incision eleven years prior to admission. Three years later, while lifting a sofa, the patient "felt something give in the incision," and developed a swelling, which proved to be a postoperative ventral hernia. It was repaired at another hospital in 1936 (seven years after onset), and recurred three months later, gradually increasing in size.

Examination on admission revealed a reducible, midline mass in the suprapubic region emerging through a defect in the abdominal wall. The abdomen was obese and the abdominal musculature was flabby. No other significant abnormalities were observed.

On March 25, 1937 the patient was operated on under general anesthesia. Through a midline incision the hernial sac was exposed, cleaned, opened, and the excess tissue removed. The defect measuring about 9 by 9 cm. was repaired by closing the peritoneum and approximating the anterior rectus sheaths with interrupted silk sutures. An anterolateral incision was then made in the right thigh and a flap of iliotibial fascia measuring 9 by 36 cm. was mobilized, but left attached at the proximal end. The flap was passed subcutaneously upward until it lay over the reconstructed abdominal wall, and was sutured at its margins to the anterior rectus sheaths. Both skin incisions were closed with black silk without drain-

age. After promptly recovering from a mild degree of postoperative shock, the patient made an uneventful recovery and was discharged from the hospital on the twenty-first postoperative day with the wound firmly healed per primam.

When the patient returned to the clinic on May 27, 1937 she had no complaints and the repair was firm. On September 20, 1937, she was again seen in the clinic at which time she complained of pain over the incision on bending. An indefinite mass which was not reducible and gave no impulse on coughing was palpable about 7 cm. above the symphysis pubis.

On September 24, 1937 the patient was readmitted to the surgical service on account of the increase in pain and tenderness over the operative site. There was no change in the physical signs and she was placed in bed for observation.

On September 28, 1937, five months following the operation, the abdominal wall was explored through a low midline incision. After reflecting the skin and subcutaneous tissue, the fascial transplant from the previous operation was found to be intact, but tense and bulging. When the flap was incised about 25 cc. of straw colored, clear, viscous fluid escaped through the incision. The incision was enlarged and the rectus sheaths beneath the transplant were found to be intact throughout. The opposing walls of the flap and rectus sheaths were smooth and glistening, forming a shallow cavity with a floor measuring about 6 by 8 cm. There were three small fibrous bands between the opposing walls, this constituting all the union that had occurred with the exception of the sutured edges of the flap.

The cavity was thoroughly evacuated and then swabbed with 3½ per cent tincture of iodine. The dead space was obliterated and the opening in the fascial flap was closed with interrupted silk sutures. The patient made an uneventful recovery and was discharged on

\* From the First Surgical Service, Hospital for the Ruptured and Crippled, New York, Carl G. Burdick, M.D., Director.

October 5, 1937. When last examined in the out-patient department on January 5, 1938, the repair was firm and she had no complaints.

and the rectus sheaths by means of suitable sutures.

The question will naturally arise as to

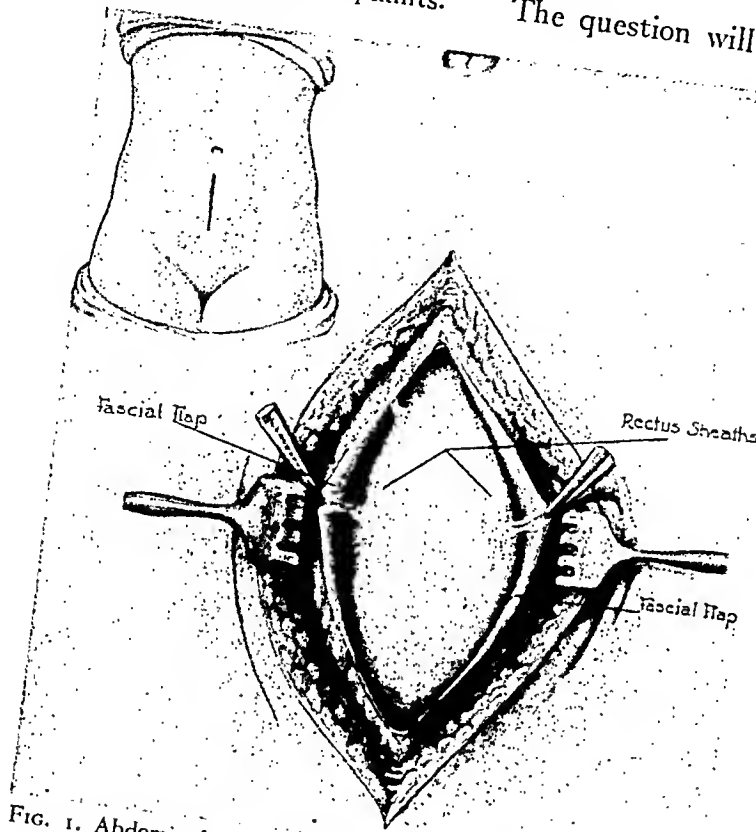


FIG. 1. Abdominal incision showing the fascial flap divided and reflected, revealing the floor of the cavity formed by the rectus sheaths.

This failure of union was presumably the result of movement of the rectus sheaths under the fascial flap leading to the formation of this bursa between them. That an interfascial bursa may develop following a Wangensteen operation can be more readily appreciated when one recalls the use of fascia lata in arthroplasty to produce investing membranes for bone ends. In the former, one may develop an adventitious bursa comparable to the artificial joint aimed at in the latter.

It is therefore suggested that in this type of hernial repair particular care be taken to obliterate the space between the fascial flap

whether this is a true bursa or a degenerating hematoma. In view of the fact that the lesion did not manifest itself until five months following the operation and then became progressively more pronounced, and in view of the findings of a smooth, glistening cavity filled with a straw-colored, clear viscous fluid without gross evidence of blood pigment, we feel that in this case we are dealing with a true acquired bursa rather than a liquefied hematoma.

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# PLACENTA ACCRETA\*

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**P**LACENTA accreta as a clinical entity was known and described before the beginning of the twentieth century, but considerable impetus was given to its study by Polak who, in 1924, discussed its incidence, pathology and management. Since then the appearance of placenta accreta in the literature, usually in the form of case reports, has not been infrequent. R. K. Smith, in 1933, added a review of the literature to his case report. Phaneuf reported two personal cases with a review of the literature comprising eighty-two cases. Recently, Irving and Hertig have reported a series of twenty cases verified by histologic examination with exhaustive and comprehensive study of all cases previously recorded. In March 1937, Mathieu reported a case of placenta accreta found at cesarean section, a situation which had been reported eight times previously.

Although the diagnosis in some of the earlier cases reported would seem to be doubtful because of the absence of histologic examinations, a summary of the etiology, pathology and management of this condition as gleaned from a study of the reports of these hundred and some odd cases would seem to be of value and is here presented. One additional case is also presented, which demonstrates many of the salient features noted in other reports.

*Etiology.* The studies of Kwartin and Adler have demonstrated three factors as the cause of this anomaly:

1. Maldevelopment of the uterus with hypoplasia of the endometrium and destructive changes of the properly developed endometrium.

2. Excessive growth of the chorionic elements.

3. Insufficient antiferment production against the erosive action of the trophoblast.

Hans Otto Neumann has emphasized the importance of the latter two factors, and several observers have pointed out that since progesterin is a factor in controlling the formation of the decidua, abnormalities of the corpus luteum may have some bearing on the formation of this condition by producing a defective decidua basalis.

Bethel Solomons stated (1933) that adherent placenta will not occur in a primipara, but since that time several cases have been reported. Placenta accreta is, however, predominantly an affection of the multiparous woman.

A history of injury to the endometrium is almost always obtainable. Previous manual extraction of the placenta is most commonly elicited. Other causes may be summarized as:

1. The performance of vigorous or repeated curettage.

2. Difficulty of separation and expression in previous pregnancies.

3. Previous endometritis and septic puerperal processes.

4. Previous miscarriages.

5. Previous cesarean section in which cases the placenta adheres at the site of the uterine scar.

6. Atmocausis or medication of a destructive or erosive type.

7. Submucous fibroids with atrophy of the overlying mucosa.

8. Faulty position of the placenta; placenta previa; attachment about the cornua, etc.

*Pathology.* Grossly the uterus is very broad from side to side, large and flabby,

\* From the Department of Obstetrics, Pittsburgh Hospital, Pittsburgh. Read before the Pittsburgh Obstetrical and Gynecological Society, October 4, 1937.

showing very little evidence of retraction. Thinning of the uterine wall beneath the placental site has been a fairly constant

the decidual septa; and (5) degeneration of the myometrium.  
Treatment. In this feature of placenta

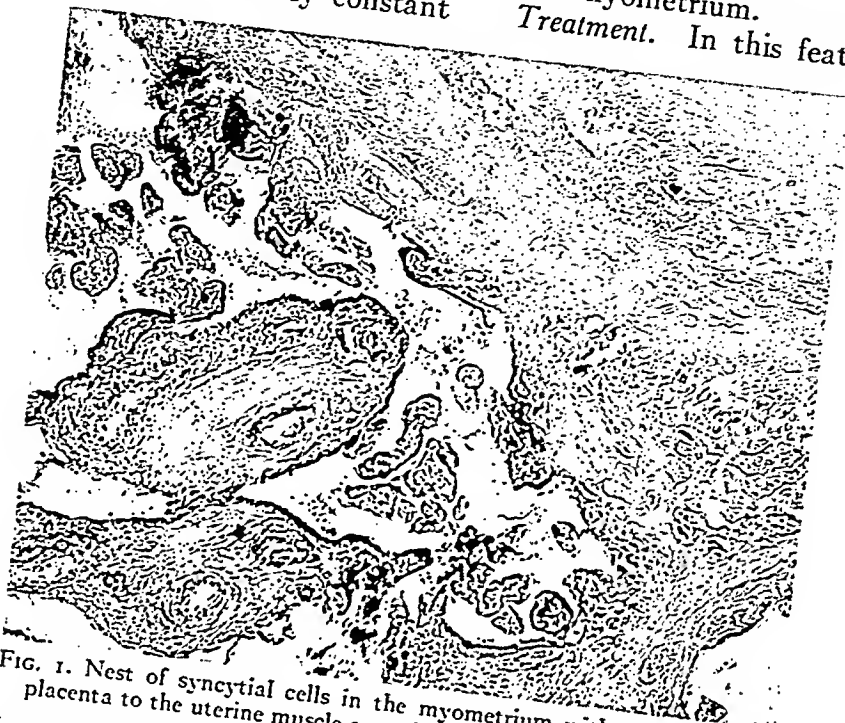


FIG. 1. Nest of syncytial cells in the myometrium with attachment of placenta to the uterine muscle over the greater extent of the section.

observation although it was not a notable feature in the cases reported by Irving and Hertig. No line of cleavage is demonstrable between the placenta and the uterine wall. Poor development of the decidua is evident.

Microscopically, changes in the decidua basalis are a constant feature. These constitute an absence or marked diminution of the decidua basalis, more pronounced in the spongy layer but in evidence also in the compact layer. Chorionic villi are attached to or deeply penetrating the uterine musculature and the myometrial veins.

The following findings have been reported as of varying constancy and significance by different authors: (1) increased connective tissue formation or scarring in the decidua vera; (2) syncytial cells found among the fibers and groups of these cells, splitting the muscle walls into fragments; (3) poor development or absence of Nitabusch's layer or, according to Dr. Mallory, penetration of this layer by villi; (4) drawing up of myometrial tissue into

accreta there is unanimity of opinion. With strictest aseptic precautions, under anesthesia, an intra-uterine examination should be made, sufficient only to determine that there is no line of cleavage between the placenta and uterine wall.

Supravaginal hysterectomy, with blood transfusion as its most valuable adjunct, is the accepted procedure.

#### CASE REPORT

Mrs. G. S., aged 44 years, gravida xi, had six children living and well and two dead. Her oldest was 24 years of age, the youngest 2 years. The third stage of labor in the last and in one of the earlier pregnancies had been difficult, with profuse hemorrhage requiring manual extraction of the placenta. There had been two spontaneous premature labors at six months. Six years before the present admission, the patient had severe hemorrhage at the expulsion of a hydatidiform mole and was subjected to curettage. She had had moderate vomiting with all her pregnancies, and on one occasion had required hospitalization for the treatment of this condition.

I first saw the patient at the Pittsburgh Hospital on March 23, 1936, after her family physician had referred her because of hyper-

hours and at 6:07 P.M. a normal male infant was extracted by the breech. No episiotomy was performed and there was no laceration.



FIG. 2. Complete absence of basal decidua with invasion of uterine veins by villi.

mesis gravidarum. The last menses had occurred October 26 to October 31, 1935. Examination revealed a pregnancy of the expected duration and a mild hyperemesis which responded promptly to appropriate measures during her six day hospitalization. Her course was uneventful until July 27, 1936, on which date she required hospitalization for several days because of a recurrence of vomiting.

On August 9, 1936 at 4:00 A.M. the patient was admitted, believing herself to be in labor. Irregular pains of varying intensity continued ineffectually throughout the day. At 9:00 P.M. a vaginal examination revealed the following: external os 2 fingers; internal os 1 finger; partial effacement; breech presenting floating high; membranes intact. The membranes were stripped from the cervix for a distance of about 2 cm. around the circumference. The following day the pains had stopped, the patient was quite comfortable and returned home.

At 8:15 A.M. on August 15, 1936 she was readmitted in labor with pains varying in frequency and intensity. These continued with great discomfort to the patient until the following afternoon, when she was prepared and a No. 6 Voorhees bag was passed through the cervix and distended. Labor progressed rapidly, the bag was expelled after several

There was no evidence of placental separation for some twenty to thirty minutes following delivery. Beyond this time a continuous dribbling of blood was present. Because of the previous history, no manipulation was resorted to until the blood loss began to be reflected in elevation of the pulse. A Crede expression was attempted and was repeated unsuccessfully under gas analgesia. About one and one-half hours had elapsed since delivery. The patient's condition was growing worse from the continued slight bleeding. Under anesthesia with strictest aseptic precautions, the uterus was invaded in an attempt to separate the placenta manually. No continuous line of cleavage could be found and the attempt resulted in quite free bleeding. The pulse was barely perceptible and the blood pressure registered below 50 systolic. The attempt having been discontinued, the patient was given 500 c.c. of acacia solution, followed immediately by 550 c.c. of whole blood transfused by the Soresi method.

Preparations for laparotomy were completed and the abdomen was opened at 8:30 P.M. A supravaginal hysterectomy was performed, removing the left tube and ovary with the uterus. The patient's condition was fair during the operation. During closure she was given an additional transfusion of 500 c.c. of whole

## Conti—Placenta Accreta

MAY, 1939

blood and was returned to her room at 9:30 P.M. in good condition.

The appearance of the uterus at operation

musculature between the fundus and the lower segment. The lower segment was filled with blood clot.

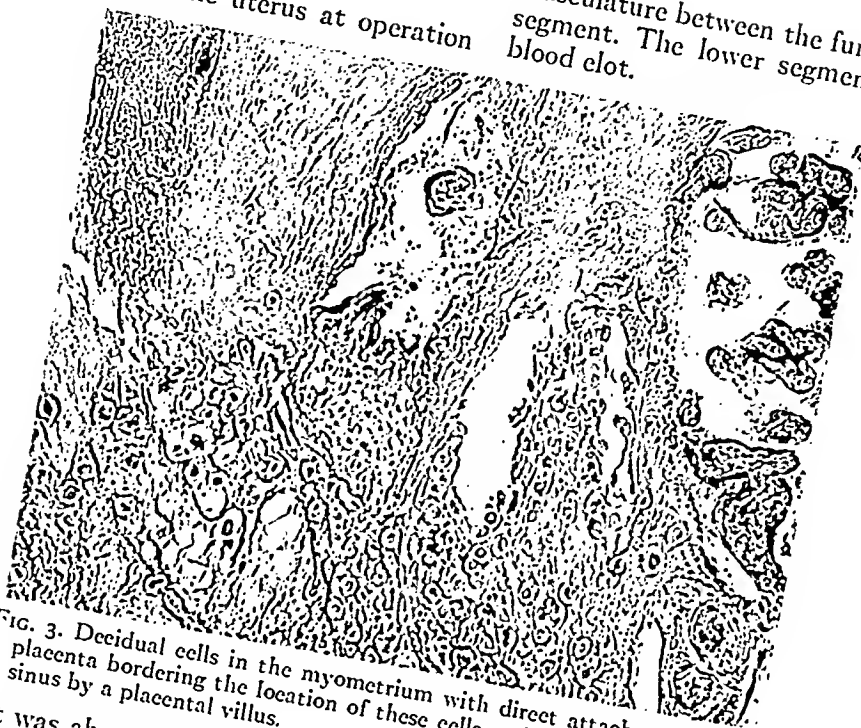


FIG. 3. Decidual cells in the myometrium with direct attachment of the placenta bordering the location of these cells and invasion of a uterine sinus by a placental villus.

was interesting. It was about the size of a six months' gestation and was broad from side to side. The fundus was firmly contracted at the

The patient was given 520 c.c. of whole blood on the second postoperative day. The convalescence was uneventful, the temperature

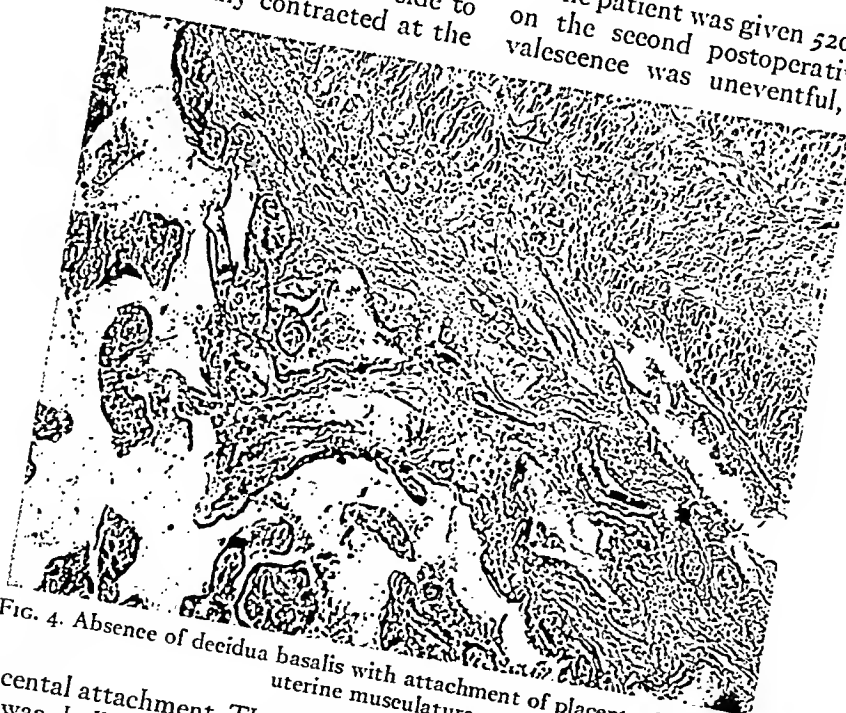


FIG. 4. Absence of decidua basalis with attachment of placenta directly to uterine musculature.

location of the placental attachment. The lower uterine segment was ballooned out so that there appeared to be a ridge of contracted

and pulse remaining normal after the fifth day. She was discharged from the hospital in good condition thirteen days after operation.

The pathologic examination of the specimen was made by Dr. J. W. McMeans whose report follows:

The specimen consisted of a uterus, the left

The placenta was firmly adherent to the posterior wall over an area that measured 9.5 cm. vertically and extended completely across the posterior surface.

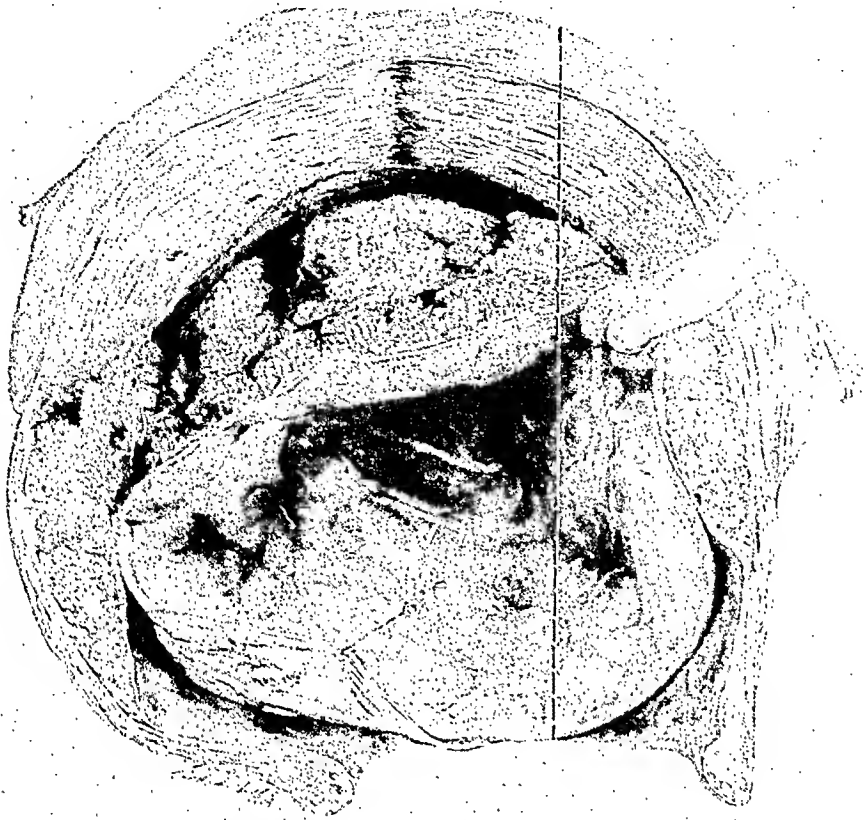


FIG. 5. Drawing of specimen after fixation in formalin solution. The areas of separation at the fundus and in the lower uterine segment are depicted. Note the excessive thinning of the uterine musculature bordering the areas of accretion.

tube and ovary. The uterus weighed 1,900 Gm. It had been amputated through the cervix. The serosa was pinkish white to pinkish red, smooth and moist, and the vessels beneath the serosa were large, thick, and tortuous.

Examination of the cavity of the uterus showed the placenta attached to the fundus and posterior wall. The placenta was oval in shape and measured 22 cm. in length by 16 cm. in width by 5 cm. in thickness. A part of the placenta which had been attached to the fundus had been separated over an area which measured 13 cm. in diameter. The intervening space was filled with currant jelly blood clot and the surface of both placenta and uterine wall was covered with thick heavy red adhesions. The shaggy appearance of these surfaces was due to an attempt to separate the placenta manually.

Inspection showed that there was no distinct line of cleavage between the placenta and the wall of the uterus. The attachment of the placenta to the wall of the uterus was demarcated by a relatively thin red layer which varied in thickness from .02 to .03 cm. This layer of tissue could not be separated without tearing the myometrium, no doubt due to the fact that it was definitely more firm than the doughy, boggy myometrium.

Extending upward from the lower border of the placenta, along the posterior wall to the level where the placenta was firmly attached and could not be separated, there was an area of 8 cm. where the placenta had apparently separated without difficulty. The decidual surface here presented a deep red swollen appearance. The cotyledons were not visible.

In this part of the placenta there were two irregularly round, yellowish-white infarcts, 3 cm. and  $4 \times 3.5$  cm.



FIG. 6. Cross section of the uterine wall at the location of the dotted line in Figure 5. Note the intimate fusion between the placenta and the uterine musculature.

The fetal surface of the placenta was normal in appearance. The umbilical cord and its vessels showed no evidence of thrombi or other changes.

Microscopic sections of the uterus showed complete absence of decidua basalis over wide areas with invasion of the uterine veins by villi. The placenta appeared to be blended with the myometrium to form bland pink-stained tissues, not unlike scar tissue in structure. There was absence of endometrium and decidua in these areas. There were many

areas where villi were intimately fused to the myometrium by heavy tissue that was not only the supporting structure of the villus but also appeared to be a portion of the wall of the uterus which extended into the villus.

An interesting feature of some sections was the presence of isolated nests of syncytial cells which were incorporated in the tissue fusing the placenta to the myometrium.

Sections through the body of the placenta showed spaces that contained numbers of leucocytes and debris with invasion of the walls of the arterioles in the supporting tissues by inflammatory cells.

In some areas, groups of lymphocytes with moderate numbers of leucocytes and plasma cells were found in the myometrium.

Pathologic diagnosis was: (1) placenta accreta partialis; (2) acute and chronic metritis (superficial); (3) acute and chronic placentitis; and (4) white infarcts of placenta.

#### CONCLUSIONS

1. The case reported is one of partial placental accretion.
2. The etiologic factors correspond with those previously reported. In addition this patient had had a hydatidiform mole.
3. The pathologic findings were: thinning of the uterine musculature beneath the areas of accretion; absence of decidua basalis; incorporation of groups of syncytial cells between the fibers of the myometrium; and invasion of the uterine veins by chorionic villi.
4. The efficacy of supravaginal hysterectomy with blood replacement as its valuable adjunct is again demonstrated.
5. Partial accretion of the placenta is of more serious import than complete placental accretion because of the continuous bleeding occasioned by the partially separated areas.

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WHEN man elected to stand up on his hind legs he undertook the hardest battle of his life, the struggle against the force of gravity.  
From—"From Head to Foot" by Armitage Whitman (Farrar & Rinehart).



# A CASE OF TUBERCULOUS OSTEOMYELITIS AND CHONDRITIS OF THE FIRST RIB\*

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OMAHA, NEBRASKA

**S**PONTANEOUS primary infections of ribs and costal cartilages are uncommon; those of the first rib rare. The following cases of tuberculous osteomyelitis and chondritis of the first rib and its cartilage is reported not so much for its rarity as a clinical entity as for its interest as an obscure and illusive diagnostic problem. In this case the inflammatory reaction surrounding the diseased rib involved the brachial plexus early and gave rise to remote neuritic symptoms of weakness, numbness, paresthesia and pain in the arm and hand of that side for a period of four months before local manifestations of the disease developed. In the absence of local evidence of inflammation and in the absence of evidence of other sources of nerve root or trunk pressure or irritation (e.g., cervical rib and arthritis of the cervical spine) a diagnosis of neuritis of unknown etiology had been entertained by the patient's physicians. Even with the appearance of swelling, tenderness and pain in the supra- and infraclavicular regions, the lesion in the first rib was not detected for some months despite several roentgenographic examinations.

## CASE REPORT

Mrs. U., age 33, entered the University Hospital January 27, 1937, for treatment of a discharging sinus in the scar of an old infraclavicular wound. She had been perfectly well until one and one-half years previous when she developed numbness and weakness of her right hand. These symptoms progressed and as they involved the arm there was a progressive loss of function and some wasting. A few weeks later there developed pain in the shoulder which at times radiated down the arm into

the fingers and was associated with burning and creeping sensations in the forearm and hand. Four months after onset she noticed swelling, tenderness and pain above and below the right clavicle. This, she was told, was either an abscess or a tumor arising probably in the "collar bone." Repeated x-ray examinations were made and reported to be negative.

The swelling gradually increased in size and the skin over it became red. In March 1936, nine months after onset, a surgical consultant explored the mass and removed some tissue for examination. A report of this examination, received through the courtesy of Dr. C. Russum, was tuberculoma of soft tissue. The patient stated that the wound healed promptly and remained healed for two weeks. It then began to drain seropurulent material and continued to do so until the present admission, ten months later.

The examination was essentially negative except for the findings in the region of the right clavicle. Immediately below and parallel to this bone there was an old scar about 3 inches long which extended laterally from the sternoclavicular articulation. Surrounding it the skin was red, raised, and indurated for an area of 3 X 4 inches. Underlying the skin there was a mass which was firm, fixed, tender, and non-fluctuant. From the center of the scar a small sinus discharged a small amount of seropurulent pus on pressure. A probe passed posteriorly contacted bone. Radiographic studies showed that the heart and lungs were essentially normal, and that the anterior end of the right first rib for a distance of an inch and a half presented considerable irregular rarefaction along its inferior border consistent with bone destruction. There was no evidence of reactive proliferation of new bone.

The urine contained a trace of albumin. The blood showed hemoglobin 78 per cent; R.B.C. 4,400,000; W.B.C. 10,700 with polys 35 per

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cent, lymphocytes 59 per cent and young 6 per cent.

The Mantoux was strongly positive and accompanied by a severe systemic reaction

The wound was closed around a small wick which was removed in four days. It healed promptly, the induration rapidly resolved and the neuritic manifestations soon disappeared.



FIG. 1. Discharging sinus in scar of previous exploratory incision. This sinus communicated with the first rib. Note swelling and inflammatory reaction about the site.

lasting two days during which there was a chill and a rise of temperature to 103 degrees.

At operation, performed February 5, 1937, the first rib was exposed and removed from its costosternal junction to a point just posterior

Microscopic examination of both bone and soft tissue showed extensive necrosis of bone with marked infiltration with lymphocytes and polymorphonuclear cells. There were a few giant cells but no tubercles.



A



B

FIG. 2. A, note areas of rarefaction in the anterior portion of the first rib and in its cartilage, and absence of proliferation of new bone. B, stump of the first rib after the diseased segment and the entire cartilage had been resected.

to the scalene tubercle. Both cartilage and bone had been extensively invaded and destroyed by granulation tissue. In several areas there were small collections of pus. With the cartilage the perichondrium and the adjacent portion of the sternum were removed. The rib was resected subperiosteally and the resection carried posteriorly until completely normal bone had been exposed.

#### CONCLUSIONS

1. A case of tuberculous osteomyelitis of the first rib is reported. No record of a similar case was found in a fairly extensive review of the literature.

2. Lesions of the first rib are of special interest as a result of close proximity to the brachial plexus and the innominate vessels

and the likelihood of involvement of these structures with remote nerve trunk and vascular symptoms in the hand and arm. Added to the confused symptomatology is the difficulty of obtaining accurate bone detail in roentgenograms of the first rib so that visualization of minor lesions is

uncertain or impossible and likely to be overlooked.

3. Cure of the above case resulted from excision of the involved portion of the rib. This undoubtedly is the best form of treatment of both pyogenic and tuberculous osteomyelitis of ribs.



THE term "flat foot" has largely been abandoned and for it has been substituted the term "weak foot." We no longer believe that the height of the arch is of great importance in relation to the efficiency of the foot. From—"From Head to Foot" by Armitage Whitman (Farrar & Rinehart).

# SO-CALLED CHRONIC THYROIDITIS WITH GIANT CELLS

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IN endemic goiter regions, the clinical and pathologic features of goiter cases, as seen in patients and histologic specimens, present (to a certain degree) a distinct regularity. Occasionally, however, cases occur which, clinically and pathologically, differ widely from the common type of goiter.

Such an instance is that type known as Riedel's struma. As the name implies, this kind of struma was first described by Riedel in 1898. It is characterized clinically by its almost iron-hard consistency and its adherence to surrounding structures, and pathologically by extensive destruction of thyroid tissue and its replacement by lymphoid and connective tissue of inflammatory origin. Subsequently, a number of similar cases were described by various authors. The best known of these was Hashimoto, who, however, believed that his four cases were essentially different from those of Riedel because of the prominence of lymph follicles instead of connective tissue. For this reason Hashimoto classified his cases as struma lymphomatosa; this view was subsequently accepted. Lately, however, Ewing, Eisen and others, having examined a number of other cases, concluded that the two conditions are in reality different stages of the same disease, and that the form analyzed by Hashimoto is the stage preceding Riedel's struma. Boyden, Collier and Bugher also entertain this opinion in their recent monograph on the subject.

Riedel had already described the process as chronic thyroiditis, and later observers agreed that the underlying pathologic process was a chronic productive inflammation. However, although Riedel's struma is now a well known and definitely circumscribed clinical and pathologic entity,

we are still far from knowing its etiology and cause. It has been well established that syphilis and tuberculosis are probably not the cause of this condition. Actinomyces, streptococcus and other bacteria have never been sufficiently proved to be of etiologic importance. Neither do embryologic considerations offer a satisfactory explanation.

Some observers, on the other hand, doubt the inflammatory nature of the disease altogether. Among these, Williamson and Pearce believe Riedel's disease to be "lymphadenoid goiter," a consequence of abnormal involution of the thyroid. The lymphocytic infiltration, from their point of view, represents only a failure of the thyroid tissue to respond with hyperplasia.

Boyden, Collier and Bugher go one step further in this direction and state that this histologic appearance (atrophy and partial necrosis of the thyroid parenchyma and increase and lymphoid infiltration of the struma) is usually caused artificially by abnormal response of certain individuals to iodine medication. They also accept inflammation as a factor, but only as a secondary one, superimposed upon a pre-existing constitutional abnormality.

According to Eisen, altogether eighty-seven authentic cases of Riedel's struma had been reported up to 1932. We have found twenty more apparently authentic cases reported from 1932-1936.

Quite characteristically, the correct diagnosis in most of these cases was made only on histologic examination. The clinical preoperative diagnosis was in almost every case malignant tumor of the thyroid. In our case also malignant tumor of the thyroid was primarily suspected and Riedel's struma was considered only as a secondary possibility.

## CASE REPORT

**History and Complaints.** The patient, a married, white female 33 years of age, was seen by one of us in October 1936. She complained of enlargement of the neck present since the age of 14 and periodically progressive in size. Simultaneously the patient observed a choking sensation and periodic nervousness. The condition became worse after the birth of her two children. The patient had been married fourteen years and had her last pregnancy one and one-half years before we examined her. She began to menstruate at the age of twelve and had no menstrual disturbances.

For fourteen years the patient frequently had had a feeling of flushing. When first seen she complained of palpitation and nervousness besides the choking sensation. She became exhausted rather easily, but her appetite was good and she noticed no loss of weight. Nothing of importance could be found in the family history.

The treatment, given the patient elsewhere, consisted of Lugol's solution, the amount and duration of which she could not remember.

**Physical Examination.** General appearance was normal, although the patient was somewhat obese. Sexual development and amount and texture of the hair were normal.

There was slight bilateral exophthalmos. The thyroid gland was slightly enlarged, its surface smooth and its consistency very firm. It was apparently not adherent to its surroundings and was somewhat tender. No nodes were felt. No abnormal heart sounds were noted. The pulse was 120 and regular.

The skin was moist and warm, the hands perspiring.

**Laboratory Findings.** R.B.C. numbered 4,130,000; W.B.C. 9,450; hemoglobin was 82 per cent; there were 68 per cent polys, 27 per cent lymphocytes, 1 per cent eosinophiles, 1 per cent basophiles and 3 per cent monocytes.

The specific gravity of the urine was 1.020 and it was negative for albumin and sugar. The basal metabolic rate was plus 32.

The clinical diagnosis made was chronic thyroiditis (Riedel) with the possibility of malignant tumor of the thyroid. In view of the diagnosis, total thyroidectomy was performed, under nitrous oxide-ether anesthesia, on December 1, 1936. The gland was extirpated after

splitting the muscles. The removal was not difficult as the gland itself was very firm and well encapsulated.

The wound secreted serous fluid for two weeks. There was marked induration of the tissue at the site of the operation, which receded in about four weeks. The patient was entirely relieved of all her complaints. The B.M.R. at discharge was minus 8. At the present time the patient receives 1 gr. of thyroid extract daily. Her B.M.R. is now plus 16 and she has no complaints.

**Pathological Report.** The specimen consisted of three pieces of thyroid tissue, one of which represented an entire lobe, while the other two were portions of the second lobe. All three together weighed 30 Gm. The first piece measured  $5 \times 3 \times 2$  cm., while the other two were  $3 \times 2 \times 1\frac{1}{2}$  and  $1.5 \times .7 \times 0.5$  cm. respectively. The external surfaces were quite smooth and covered with a fibrous semi-transparent capsule of a pinkish gray color. Only on the smallest segment was the external surface of a slightly nodular appearance. The consistency of all three pieces was very firm, similar to that of a fibroma.

On multiple sections the cut surfaces presented nothing resembling the normal architecture of the thyroid gland. Instead, the cut surfaces were of a yellowish gray color and of an almost homogenous appearance. On close inspection they revealed only a white, netlike pattern separating small lobules of firm yellowish gray tissue. The smallest specimen was of slightly less firm consistency and on section, appeared a yellowish brown color; also the lobular architecture so typical for the thyroid still could be distinguished, although the septa appeared wider and much more branched than normal.

Microscopically, the capsule was markedly thickened by the increase of fibrous connective tissue. It contained small groups of lymphocytes, which, however, formed no follicles. The connective tissue likewise was very markedly increased throughout the entire thyroid. It was infiltrated by variously sized groups of lymphocytes, fibroblasts, histiocytes and not very many plasma cells. This connective tissue occupied more than one-half the bulk of the entire organ and enclosed scattered remnants of the thyroid parenchyma in various stages of degeneration. The largest of these consisted of groups of not very large

thyroid follicles, which contained pale staining homogenous colloid and were lined with one layer of flattened epithelial cells, while other

staining colloid material. The connective tissue surrounding and separating these structures was generally only moderately infiltrated by



FIG. 1. Degenerating follicles. Note giant cells in follicles around colloid. ( $\times 150$ ).



FIG. 2. Degenerating follicles. Note giant cells. ( $\times 150$ .)

follicles in the same group contained but desquamated epithelial cells. There were other follicles scattered throughout the tissue in which the epithelial lining had completely disappeared, or was at least not recognizable as such. The lumen of these follicles contained small and large particles of pink-staining amorphous material (colloid), surrounded by

lymphocytes and was more fibrous than elsewhere. There were, however, glandular structures in other areas which were surrounded by thickly infiltrated connective tissue. These structures contained colloid and more desquamated cells than the others described above.

Pathologic diagnosis was so-called chronic thyroiditis (Riedel's struma).

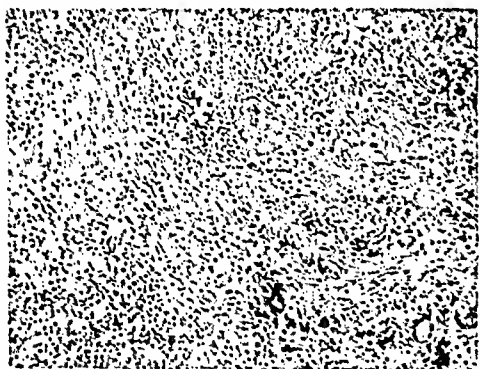


FIG. 3. Area of chronic inflammation. No thyroid parenchyma present. ( $\times 150$ ).



FIG. 4. Granulation tissue with follicle remnants and giant cells. ( $\times 150$ ).

numerous giant cells usually with eccentric nuclei, lymphocytes and fibroblasts. The markedly increased stroma between these follicles was infiltrated with a large number of lymphocytes, histiocytes and fibroblasts. Giant cells in smaller groups were also found in close proximity to these follicles, their arrangement similar to that of the giant cells within the follicles. Finally, there were also scattered groups of distinctly glandular structures, generally small and lined by a single layer of cuboidal epithelial cells, and apparently either empty or containing some very pale pink-

#### DISCUSSION

From the pathologic point of view, the histologic changes seemed to represent exhaustion atrophy in part and in part, attempts at regeneration of thyroid parenchyma, both processes being apparently simultaneous and in various stages. The inflammatory and fibrotic processes in the stroma, which were also present, may be interpreted as secondary—the expression of connective tissue reaction to the pathologi-

cally increased degenerative and regenerative process in the parenchyma. From the histologic aspect the giant cells seen in

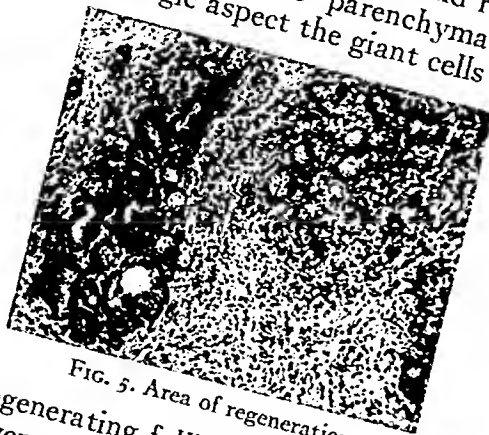


FIG. 5. Area of regeneration.

the degenerating follicles and their former sites were very interesting. Clearly, they were functionally foreign body giant cells, mostly found surrounding colloid particles. However, in contrast to the general view of foreign body giant cells as being of mesodermal origin, these cells were partly morphologically recognizable as formed by the fusion of epithelial follicular lining cells. The site of other giant cells found here at least suggested a similarity in their development. Kaufmann, Gordon Lee and Nestman also interpreted the giant cells found in some of their cases as of epithelial origin.

From the clinical standpoint this case was remarkable for the long duration of the symptoms, their first appearance during puberty and their increase in severity during and after pregnancies. These features, in our opinion, seem to indicate that in this case a causal relationship may have existed between the condition of the thyroid and changes in the balance of the endocrine system. Of course, the interdependence of the entire endocrine system, including the thyroid gland, is now in general regarded as a well known and established fact, although many of the details are still lacking. Structural changes of the thyroid depending upon numerous extrinsic and intrinsic factors (geographic location, food, age, sexual cycle, pregnancy, etc.) have also been extensively studied and are recognized as physiologic.

One may regard the condition of the thyroid gland in this case as the consequence of abnormal response to physiologic demands, increased especially in puberty and pregnancies. A somewhat similar view has been expressed by McKnight, who suggested the secretion of some as yet obscure biochemical irritant, differing from that produced in exophthalmic goiter as the cause of Riedel's struma. Inconsistent with this theory of qualitative chemical difference in thyroid secretion, however, is the fact that in our case a slight exophthalmos and elevation of the B.M.R. to plus 32 was observed.

The hypothesis of Boyden, Collier and Bugher, who regard Lugol's solution as the causative agent, does not seem to be quite convincing in this case, as the patient had not received this drug in great quantities or for a long time. It also seems to us that Riedel's struma was observed before Lugol's solution was used for goiter therapy.

#### THERAPY

There appears to be no absolute agreement upon the subject of therapy. Some authors (Riedel, Eisen, Gordon Lee and others) advise partial resection of the gland, while others (McKnight, Nestman, etc.) advocate complete resection. In our opinion partial resection is not advisable because the correct clinical diagnosis of Riedel's struma is almost impossible. A malignancy must always be suspected until the histologic examination has clarified the diagnosis. Even the correct histologic differential diagnosis between carcinoma and Riedel's struma may be very difficult and occasionally impossible. For this reason we believe total thyroidectomy to be the correct therapeutic method in chronic thyroiditis.

#### CONCLUSIONS

A case of chronic thyroiditis with giant cells (Riedel's struma) in a woman aged 33 years has been presented. The condition is believed to be caused by abnormal



response of the thyroid to physiologic demands. The histologic changes are interpreted as primarily de- and regenerative rather than inflammatory. Total thyroidec-tomy is advocated.

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GENERALLY speaking a palpable thyroid gland that is firmer than normal may be regarded as a goiter to the extent that it is a disturbed thyroid gland which requires treatment. . . . On the other hand, a thyroid gland may be obviously enlarged, therefore a goiter, which is even softer than normal.

From—"Diseases of the Thyroid Gland" by Arthur E. Hertzler (Mosby).

# PRIMARY SARCOMA OF THE LIVER: ENDOTHELIOBLASTOMA\*

## CASE REPORT

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**O**FTEN the site of tumor metastases, the liver is rarely the host of primary cancer. In 1924, Goldstein collected fifty-nine cases of sarcoma and 250 cases of carcinoma of the liver. Since then approximately thirty new cases have been recorded. In 1933, Kundstadter had collected fifteen cases occurring in infants. However, confusion in classification of these mesenchymal hepatic tumors makes an accurate count difficult. The histologic rôles of primary sarcoma of the liver are protean, and varied interpretations of the cytology obscures classification. There is direct evidence that both the connective tissue and the endothelial cells of blood vessels and Kupffer cells are susceptible to tumor growth. Superfluous mesodermal tissue has also accounted for origin in reported hepatomas. Kupffer cell tumors have shown myeloid tissue suggesting that some focus of endothelial cells assumed the hematopoietic capacity possessed in the embryo.

Primary mesodermal tumors of the liver have been described as spindle and round cell sarcomas, giant cell angiosarcomas,<sup>22</sup> chrionepitheliomas,<sup>22,32</sup> hemangio-endotheliomas,<sup>38</sup> angio-endotheliomas,<sup>52</sup> and peritheliomas.<sup>27</sup> Ewing<sup>8</sup> has divided them into angiosarcomas, alveolar sarcomas, spindle and round cell sarcomas. Primary melanoma of the liver is hard to establish. Rolleston<sup>22</sup> refers to nine reported cases and notes that no case is authenticated unless the uveal tract is explored after death. Cases in which portal cirrhosis and primary sarcoma were associated have been

described,<sup>16,20,23,26,43</sup> as hemangio-endotheliomas, and are considered to have arisen from Kupffer cells and not from the vascular endothelium. Cases of cirrhotic liver have presented both sarcomatous and carcinomatous processes<sup>11,21,22</sup> with the former process in these cases arising from connective tissue. Hemangio-endotheliomas of Kupffer cell origin have even occurred in normal livers. Tumors arising from the endothelium of the portal vein<sup>16</sup> are also recorded. Some tumors arising from Kupffer cells have presented myeloid tissue in the tumor.<sup>9,23,35,44</sup>

Ewing has failed to include these tumors, described by numerous writers as hemangio-endotheliomas and thought to arise either from the endothelial cells of Kupffer or from blood vessels. Mallory<sup>30</sup> separated the slow growing tumors with definite blood vessels, the angiomas, from those in which the cells grew rapidly and proliferated into solid masses, the endotheliomas. Those arising from blood vessels he termed hemangio-endotheliomas and considered true blastomas. Schultz<sup>45</sup> suggests the term endothelioblastoma for the malignant forms to distinguish them from malignant fibrous tissue tumors or sarcomas. It may be well to speak of those tumors arising from the Kupffer cells as endotheliomas or blastomas and those derived from the vascular endothelium as hemangio-endotheliomas or blastomas, depending on the benignity or malignancy. Those arising from the connective tissue stroma of the liver may be rightfully termed sarcomas. It is generally conceded that symptoms and findings of malignant tumors of the liver do not differ materially, whether the

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growth be primary, secondary, sarcomatous or carcinomatous. Some cases are asymptomatic; others show a latent malignancy

abdominal veins in 30 per cent. Enlargement of the abdomen, constipation, hemorrhoids and jaundice are not infrequently

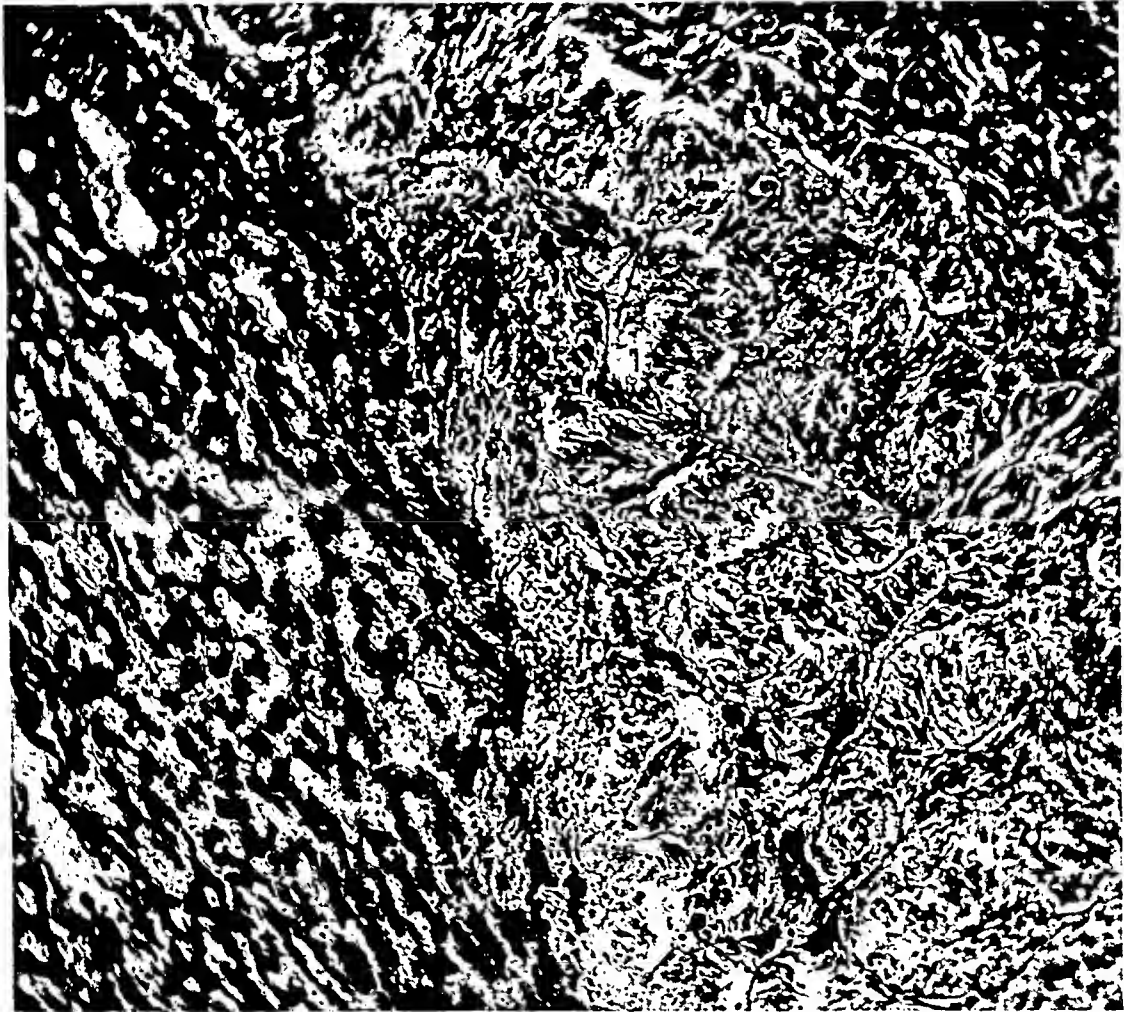


FIG. 1. Low power, showing spindle-shaped neoplastic cells arranged in parallel bundles and in an alveolar manner (right half of field). The fine reticulum is seen as fine black lines between the alveolar masses. Invasion of the liver parenchyma is observed midfield.

and patients succumb to other hepatic disease. Some patients give a history of cirrhosis with hepatic tumor, jaundice ascites and cachexia. Finally, there may be simply a history of a hepatic tumor mass.

Foote<sup>10</sup> reported nine cases of primary hepatic hemangio-endotheliomas, all observed in children, and he concluded that these tumors were peculiar to infancy. However, the older<sup>22</sup> and more recent literature records numerous cases in adults.

Hepatomegaly and right upper quadrant masses are probably the most constant findings. Progressive loss of weight and strength are noted frequently. Ascites is seen in 50 per cent of the cases and dilated

recorded. The last symptom depends on the relation of the tumor mass to the biliary duct system. Pain, although not an early or persistent symptom, usually appears during the course of the disease. It has been attributed to distention of the capsule and localized peritonitis. It is usually distributed in the lumbar, flank or shoulder regions.

Grossly, the liver may or not be enlarged. Kaufmann<sup>22</sup> cites a case with large cysts the size of a child's head in which the liver weighed 10,900 Gm. The masses of tumor tissue usually appear as round firm nodules extending from the liver surface as truffle-like globules. They

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may infiltrate, may be well demarcated or even encapsulated. They vary in size from small miliary areas to large masses 10 or more centimeters in diameter. The sarcomatous nodules vary in color from gray, red, brown to black. They may be cystic, fluctuant, especially if they are vascular. Cellularity and degeneration may make them very hard and firm. The masses may be discrete or conglomerate. Sometimes, a large solitary growth may be mistaken for a primary tumor or tumors of the adrenals and the sympathetic ganglions (neuroblastomas) may invade the liver and confuse the primary source. Umbilication of the surface of the liver, seen in carcinoma, is rare in the sarcomas.

The cells may spread by the blood stream, by direct continuity, by regional lymphatics or by way of direct extension in the lumina of the hepatic blood vessels. The adult host usually presents a tumor of greater endothelial proliferation and more frequent tendency to metastases and infiltration. Secondary colonies, both in infants and adults, have been observed in the regional lymph nodes, lungs, adrenals, spleen, skull, vertebrae, ribs, skin, mesentery and diaphragm. However, the primary mesodermal tumor of the liver may be malignant without metastases.

Histologically little need be said of sarcomata of stromal origin; their morphology is that of round and spindle cell fibrosarcomas elsewhere. Those arising from the vascular or Kupffer cell endothelium of the liver, on the other hand, show considerable pleomorphism. Such neoplasms vary with the cell of origin and the degree of malignancy. In the more benign forms, the tissue presents dilated blood spaces lined by endothelial cells and separated by mature connective tissue. The endothelial cells may be several layers deep and larger and more numerous than normally, while the nuclei are vesicular, oval to fusiform in shape and present no mitoses. In the more undifferentiated states, the tissue may be a mass of cells with small openings lined with endothelial

cells and filled with erythrocytes. There may be a layering of the cells concentrically, as is seen in dural endotheliomas. Papillary ingrowths have been noted. In children, the tumor is usually differentiated and mitoses rare. However, encapsulation may be lacking.

In the more malignant forms, most frequently seen in the adult, sheets of polyhedral cells are continuous with the swollen endothelial cells lining the vascular spaces. The undifferentiated character of the cells and numerous mitoses testify to malignancy, and there is local expansion, accompanied by infiltration and the presence of malignant cells in the lymphatics. The tumor may not form a reticulum but is a part of the original hepatic framework.

In association with cirrhosis the hepatic tissue may show irregular regeneration of cells with coarse fibrosis and bile duct proliferation—the picture of portal cirrhosis. In certain areas of regenerated parenchyma, there is a marked cellularity of the hepatic capillaries, an unusual number of lining cells, swollen and deeply stained, and it may be difficult to deny the transition between the sarcomatous infiltrating process and these areas. It is controversial whether the cirrhotic process may have progressed into a neoplastic response or whether the regeneration is a balance between the spindle cells in the more differentiated areas of the tumor and the hyperplastic cells of the regenerated areas is striking.

The cells in the most malignant tumors are large embryonal spindle cells with hyperchromatic nuclei and active mitoses. The cells appear as small nests, groups, or sheets infiltrating the liver and sending out dendritic strands into the surrounding areas. The blood vessels are immature, often with thrombosis and organization. In those endothelial tumors arising from the Kupffer cells, vascular sinuses are not a prominent feature and the tumors are more cellular in type. Ross and Gray have each reported tumors which they believe have

arisen from the endothelium of the portal veins.<sup>34</sup>

The most frequent tumor arising from vascular endothelium, the angioma, is fairly common and of varying malignancy; such a growth may replace an entire lobe.<sup>34</sup>

The final stage results in metastases from the undifferentiated neoplasm. Ogilvie and MacKenzie range the tumors in order of increasing malignancy as follows: (1) simple angioma (histologically benign); (2) malignant angioma (metastases which are histologically benign, as is the primary mass—e.g., Sheenan's case); (3) malignant hemangio-endotheliomas (histologically malignant with metastases—e.g., Ogilvie and MacKenzie's case).

The paucity of cases leaves much to be desired clinically, but pathologically the reports show remarkable constancy and little doubt of the nature of the histological picture. Such tumors are worthy of a separate classification as hemangio-endotheliomas (blood vessel origin), endotheliomas (non-vascular origin) and endothelioblastomas (malignant in character).

#### CASE REPORT

W. B., white male, 76 years old, was admitted to the hospital April 24, 1936 with a diagnosis of senile psychosis. At no time up to his death on December 20, were there symptoms referable to the hepatic system.

Autopsy showed that the liver was 5 cm. below the right costal margin. The surface of both lobes was studded with grayish-brown nodules, firm and well demarcated, and from 1 to 5 cm. in diameter. On cut section, many of the nodules had central necrosis and hemorrhage. The greater part of the left lobe was replaced by tumor tissue. In addition there was a myocardial hypertrophy and fibrosis, arteriosclerosis, arteriosclerotic nephritis and cerebral arteriosclerosis.

**Histology.** Sections of the liver contained nodules of fairly well demarcated circular masses of the neoplasm. These nodules were made up of spindle-shaped cells, arranged in an alveolar manner and containing large nuclei of coarse chromatin granules and well defined, deeply staining nucleoli. The cytoplasm was

irregular, having a tendency to form a syncytium with neighboring cells. The cells were distinctly granular and tended to arrange themselves in parallel rows or groups, in many places away from an elongated empty space. At the periphery of the masses, there was a moderate invasion of the liver parenchyma which was compressed. There are very few mitotic figures, but some of the peripheral cells are enlarged and anaplastic.

A fine network of blue-staining reticulum was demonstrated with Mallory's aniline blue stain, much of it coarse and resembling that of the normal liver stroma. However, there was also a very fine reticular felt-work, evidently laid down by the neoplasm and arranged as radiating fibers. The neoplastic cells occasionally showed a brown granular pigment demonstrated with Mallory's Prussian blue stain to be hemosiderin.

The remainder of the liver showed some cloudy swelling and fatty degeneration of the hepatic cells.

Failure to find another primary site upon careful search at autopsy and the absence of metastases in such customary places as lungs and abdominal lymphatics strongly favored a diagnosis of primary hepatic neoplasm. Moreover, the massive involvement of the left lobe of the liver with numerous metastatic nodules in the right lobe substantiated such an assumption. The nodules in the right lobe varied in age, as was evidenced by the varying size and amount of stroma. It is reasonable to conclude that this neoplasm was a primary alveolar spindle cell sarcoma of probable endothelial (vascular) origin (a hemangio-endothelioblastoma).

#### SUMMARY

A review of the literature on primary hepatic sarcomas of endothelial cell origin is made and a case reported.

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# DIVERTICULUM OF THE ANTERIOR URETHRA IN A MALE CHILD\*

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**D**IVERTICULUM of the anterior urethra in male children, judging from the scarcity of reported cases had experienced difficulty in urination, dribbled intermittently and was a persistent bed wetter. Various remedies and home cures had been



FIG. 1. Retrograde urethrogram, anterior, posterior view.



FIG. 2. Retrograde urethrogram, lateral view.

is a rare congenital malformation of the genitourinary tract. A recent survey of literature by H. L. Kretchmer<sup>1</sup> revealed only twenty-one cases, including his own.

Since the condition is still an anatomic curiosity and clinically is of unusual interest because of the serious pathology which it eventually causes, we wish to report the following case:

P. H., 6 year old male, was admitted to Lincoln Hospital on December 26, 1936, on the service of Drs. Dwight and Martin (to whom we are indebted for the privilege of reporting this case). The history obtained from the mother was that from early infancy the child

tried without success. As the patient grew older the condition became progressively worse and there was relatively little control over the act of micturition. He was able to void voluntarily only a few drops at a time and only with great effort. The dribbling became continuous night and day and was often associated with spells of convulsive crying and picking at the genitals. Skin eruptions were frequently present on the thighs and scrotum from the irritation of the ever present dribbling urine. The child reeked with a pungent urinous odor. Mentally the boy was slowly getting very dull and morose, and periodically would go off by himself refusing to eat or play.

The boy was pale and somewhat underdeveloped and he appeared extremely anxious

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and frightened. His head, neck, heart and lungs were essentially negative. There was slight tenderness over the suprapubic region with a



FIG. 3. Intravenous pyelo-urethrogram, anteroposterior view.

3,500,000; W.B.C. 14,600. Temperature at this time was 100.2 rectally. The next day a urethro-gram made by injecting 25 per cent skiodan through the external meatus disclosed a round shadow about the size of a small egg connected with the urethra. (Fig. 1.) A lateral roentgenogram showed a shadow about  $2\frac{1}{2}$  inches long and located in the anterior urethra. The posterior urethra could be seen extending into the bladder. (Fig. 2.) The bladder was outlined in this procedure and was definitely enlarged. (Fig. 1.) Diverticulum of the anterior urethra was diagnosed.

Intravenous urograms taken the next day showed bilateral hydronephrotic kidneys with tremendously dilated pelvis and blunted calyces and large tortuous sausage-like ureters emptying into a distended bladder. (Fig. 3.) The diverticulum was also visualized in these films, confirming the diagnosis.

Operation was advised, but before consent was obtained the skin over the diverticulum became red, tender and indurated. This induration spread around the base of the penis and into the groins. The skin here became tense and edematous followed shortly by bullous eruptions and spreading edema of the lower abdominal wall. (Fig. 4.) At this time the patient became very stuporous, his temperature rose rapidly to 107 degrees and before any surgical intervention was possible, the child became comatose and died. Antemortem blood chemistry showed NPN 140 mg. per 100 c.c. of blood.

Examination of the genitourinary tract at autopsy revealed two large pyonephrotic kidneys and pyoureters (Figs. 3 and 5) with very little renal parenchyma present.

Calyces and pelves were markedly dilated and filled with purulent urine. A post-mortem culture revealed *B. coli*. The bladder was dilated and thickened. The muscular wall was hypertrophied to about the consistency of an adult heart muscle. There were no congenital anomalies noted in the bladder or upper urinary tract. The urethra appeared normal from the vesicle neck to the junction of the bulbous and penile portion where there were two openings found in the floor that were about the size of small peas. These opened into a common diverticular sac which was about the size of a golf ball. Closer examination of the sac revealed a pin point perforation in its most dependent portion with extravasation of urine

mass which, though not definitely palpable, suggested a distended bladder. The penis was small with marked phimosis. The glans was normal, and there was neither hypo- nor epispadias. At the base of the penis and in the upper part of the scrotum in the midline there was a round bulge about the size of a pigeon egg. This was tender and fluctuant, and when it was squeezed, urine was expressed from the external urethral meatus. After its contents had been emptied by compression, the mass refilled in five minutes. The testicles were both present and apparently normal. Circumcision was done to relieve the phimosis. While this was being carried out a mass appeared in the upper part of the scrotum and became larger while we watched. The operation was completed and the patient was returned to the ward.

Urine collected by manual expression showed a trace of albumin, 4 plus W.B.C. Clumps were present and 30 to 40 R.B.C. per high power field. Blood chemistry showed NPN 75; urea 42. Hemoglobin was 65 per cent; R.B.C.

into the scrotum, groin and lower abdominal wall. The skin over these latter areas was discolored and had begun to break down. (Fig. 4.) Death was ascribed to acute urinary sepsis.

2. The diagnosis was confirmed by urethrograms and intravenous pyelograms.

3. Intravenous pyelograms and autopsy revealed huge pyonephrotic kidneys and

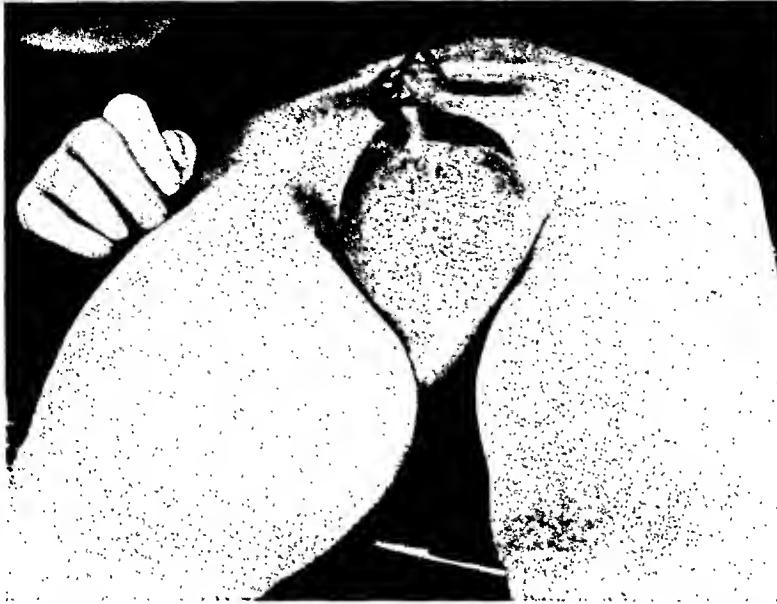


FIG. 4. Photograph of patient showing edema of the scrotum and necrosis of skin over diverticulum



FIG. 5. Autopsy specimen.

#### COMMENT

1. A diagnosis of diverticulum of the anterior urethra was made in a case which presented symptoms of long standing urinary difficulties with enuresis and constant dribbling as the primary complaint. The signs noted were a soft fluctuant mass in the upper part of the scrotum at the base of the penis which, when compressed, discharged urine through the external meatus.

pyoureters with pyelonephritis as the result of long standing obstruction and infection.

4. The obstruction to the free flow of urine in this case was undoubtedly due to the hydrostatic mechanical pressure caused by a full diverticular sac compressing the lumen of the urethra. This resulted in retention and dilatation of the bladder and upper urinary tract with stasis, infection and destruction of renal tissue. Similar

findings were reported by J. Bokay<sup>2</sup> in two cases and by Ternovsky<sup>3</sup> in one case.

5. The perforation of the diverticulum and concomitant extravasation of urine into the surrounding tissues in this case was evidently the result of pressure exerted on an already over-distended, infected, and thinned out pouch, while trying to void forcibly.

This complication with extravasation has not been reported previously. In Kretchmer's case, there was perforation through a fistulous opening made through the skin with discharge of urine and pus externally, but no extravasation of urine into the surrounding tissues was noted.

#### CONCLUSIONS

An unusual anatomic anomaly of the urethra in a male child is reported with enuresis and dribbling as the primary symptoms.

The usual complications of urinary obstruction were present, resulting in death by sepsis before surgical intervention was possible.

This case emphasizes the importance of early examination and recognition of the cause of urinary difficulties in infants, especially those of an obstructive character.

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# RUPTURE OF INTESTINE FROM FORCEFUL PROTRUSION OR REDUCTION OF HERNIA\*

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**P**ERFORATION or rupture of intestine that has become gangrenous as the result of strangulation in a hernial sac, is not an unusual occurrence. It may be the result of spontaneous necrosis entirely, or of force applied ill-advisedly in attempts at reduction. By the time such perforation occurs, the neck of the sac has often become sealed off by the inflammatory reaction, and the gangrenous bowel with its leaking content may be entirely confined to the interior of the sac without free communication with the general peritoneal cavity. Opening of the sac, and establishment of drainage to the exterior, may well relieve the obstruction and control the infection, without the need for intraperitoneal intervention at the time of the emergency.

Perforation or rupture of apparently normal intestine, non-strangulated, only transiently incarcerated in a hernial sac, and previously readily reducible, may result from force applied to the hernia directly, whether by vigorous attempts at reduction, or by contusion. This is a much rarer happening, not more than 100 cases having been reported in the literature. Undoubtedly, more such accidents have occurred than have been reported, yet the total must still be relatively small.

Rarer still is the occurrence of perforation or rupture of apparently normal intestine in an individual who is the possessor of a readily reducible hernia, not strangulated, and not even transiently incarcerated, as the result of a heavy lifting strain, or other excessive muscular effort, or as the result of contusion applied to the abdomen at a distance from the hernial site. In such cases there may have occurred

an unusually forceful protrusion of the hernia at the time of the strain or blow, but in some instances even this unusually forceful protrusion has not occurred, or at least has not attracted the attention of the patient at the time of the accident. Altogether, not more than three dozen or so cases of this type have been reported, though here again, undoubtedly, more have occurred than have been reported.

When perforation or rupture of intestine occurs under the variety of circumstances just enumerated, and the injured intestine spontaneously slips back, or is forcefully pushed back into the peritoneal cavity, leakage of intestinal content produces a rapidly developing peritonitis, and a serious surgical emergency exists.

The rarity of these accidents, and the gravity of their consequences, which demand an early intra-abdominal surgical intervention, prompt the reporting of the following case history, with the view of adding to the relatively small number of cases on record, and of emphasizing the danger that threatens the possessor of a hernia which is subjected to forceful protrusion or reduction.

## CASE REPORT

M. K. male, aged 57, a house painter by trade, was admitted to Beth Israel Hospital on October 13, 1936, at about 1:00 P.M. as an emergency case.

He had had a right femoral hernia for about fifteen years, always theretofore readily replaceable and well retained by a truss. His general health had always been good. About 9:30 A.M. of the day of admission to the hospital, while at work, he had occasion to lift a 5 gallon can of paint, a weight of about 85 pounds. As he

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did so, he felt the hernia come out forcefully in spite of the truss. He immediately experienced pain at the hernial site. He tried to reduce the hernia through his clothes, met with considerable difficulty, and applied more force than usual. As he finally pushed the hernia back, he felt "something tear inside." He at once began to suffer severe pain in the lower abdomen, increasing in intensity, and spreading steadily further upward, though remaining maximal in the lower abdomen. He felt nauseated, but did not vomit. He delayed seeking medical aid in the hope that the pain would subside, and it was some three hours after the accident before he was admitted to the hospital.

Physical examination showed the patient to be in acute distress from abdominal pain; his face appeared anxious and his legs were drawn up. Temperature was 98.6, pulse 108, respirations 24, blood pressure 140/90. A right femoral hernia was readily demonstrable, soft, compressible, and quite easily reducible. The abdomen was generally tender and rigid, almost boardlike in quality, particularly in the lower quadrants. Tenderness, direct and rebound, was most marked just above the pubes to the right, and above the right Poupert's ligament. Blood count showed a hemoglobin of 110, R.B.C. 5,800,000, W.B.C. 32,350, with 82 per cent polymorphonuclear cells.

The impression gained was that during the forceful protrusion or reduction of the hernia, a rupture or perforation of gut had occurred, and with replacement of the injured bowel into the peritoneal cavity, a spreading peritonitis was rapidly developing.

An x-ray (flat plate) of the abdomen failed to show evidence of free fluid or gas in the abdomen.

A laparotomy was performed under spinal anesthesia about seven hours after the accident had occurred. After the opening of the peritoneum through a lower right rectus splitting incision, yellowish, odorless, somewhat turbid fluid, in considerable amount, was encountered and suctioned off. Fibrinous exudate was scattered about over intestinal loops. Inspection of the femoral sac showed that it was in its natural situation (no reduction en masse), empty of content, with the peritoneum at the neck showing a number of reddish ecchymotic spots of 2 to 3 mm. size. A short hunt disclosed a loop of ileum lying in the right lower quadrant which showed the seat of injury.

At this site, the adjacent mesentery showed a triangular segment, which appeared greenish black, and edematous. The ileum showed what appeared to be a small perforation directly at the mesenteric attachment, leaking its content slowly into the tissue between the two leaves of the mesentery.

The gangrenous portion of mesentery over a width of 5 cm. was definitely compromised, and this made a simple suture of the perforation out of the question. Therefore, a resection of a segment of intestine and mesentery, embracing the perforation and gangrenous mesentery, altogether about 7 inches in length, was performed. The ends of the divided gut were closed with an inverting suture of chromic catgut drawn tight as the Payr clamps were withdrawn, reinforced by a purse-string suture of Pagenstecher linen thread. Then, a side to side anastomosis was effected, using No. 0 chromic catgut for the inner layer, and Pagenstecher linen for the outer layer of closure. The opening in the mesentery was closed with several interrupted plain catgut sutures. A rubber dam drain was placed in the pelvic cul-de-sac, and the abdomen was closed in layers.

Repair of the femoral hernia was deferred till such time as the patient would recover from this acute and serious emergency.

The patient's postoperative course was essentially uneventful. Moderate distention and regurgitation were overcome by use of the Levine tube and enemata. The bowels moved freely. The drain was shortened gradually, and was finally removed on the fifth day. A mild wound infection at the lower angle in the region of the drain quickly subsided. The patient was discharged from the hospital on the twentieth postoperative day. The right femoral hernia was still present, readily reducible, and held in place by a well fitted truss.

A culture of the fluid in the peritoneal cavity was reported as showing a growth of staphylococcus albus hemolyticus.

*Pathologic Report* (Dr. Alfred Plaut). The specimen was an 18.5 cm. length of intestine with attached mesentery, the mid-portion of which, at the junction of mesentery and intestine, showed on one side a dark, slate colored area, 2 × 1.3 cm., (appearing larger on stretching), partly on intestine and partly on mesentery, sharply triangular in outline.

On the other side of the mesentery there was a corresponding area,  $1.2 \times 3$  cm. Fine masses of fibrin were scattered over the surface of

of rupture. No evidence of preëxisting disease in the intestinal wall was demonstrable.

The pathological diagnosis was: Tear of



FIG. 1. Very low magnification. The perforation is seen extending through the whole thickness of the intestinal wall in spiral fashion. M, mucosal end. S, serosal end of the perforation.

intestine and mesentery. On the mucosal surface of the intestine, a greenish ovoid spot was present, 4 mm. in diameter. On cutting through the intestinal wall at this site, we found a small, round, reddish mass protruding through a gap in the muscle coat into the outer layers.

The microscopic examination showed a perforation of the intestinal wall, with mucosa reaching to the outside of the intestine into the mesentery through this break in the wall. (Fig. 1.) The whole region was severely inflamed, while the edges of the perforation appeared partly necrotic. (Fig. 2.) Masses of torn mucosa lay outside the intestine. The fat tissue of the mesentery was widely necrotic and inflamed around particles of intestinal content which had leaked into the mesentery. (Fig. 3.) The area of necrosis and inflammation was many times larger than the actual area

small intestine; circumscribed necrosis of intestinal wall and mesentery.

#### COMMENT

In this case the perforation of intestine may have occurred at the time of forceful protrusion of the hernia, when the patient first experienced pain at the hernial site, or during the act of forceful reduction, when he felt "something tear inside" and began to suffer severe pain in the lower abdomen. Or, it is possible that an injury to the intestine during the forceful protrusion was aggravated and completed by the act of reduction.

A similar case in the literature is that of Gangl,<sup>1</sup> whose patient, a beer truck driver with a left inguinal hernia which was

readily reducible; experienced severe lower abdominal pain immediately following the lifting of a heavy keg of beer, when his

duced and as readily reduced, as before the accident.

Hilgenfeldt<sup>5</sup> has reviewed the literature

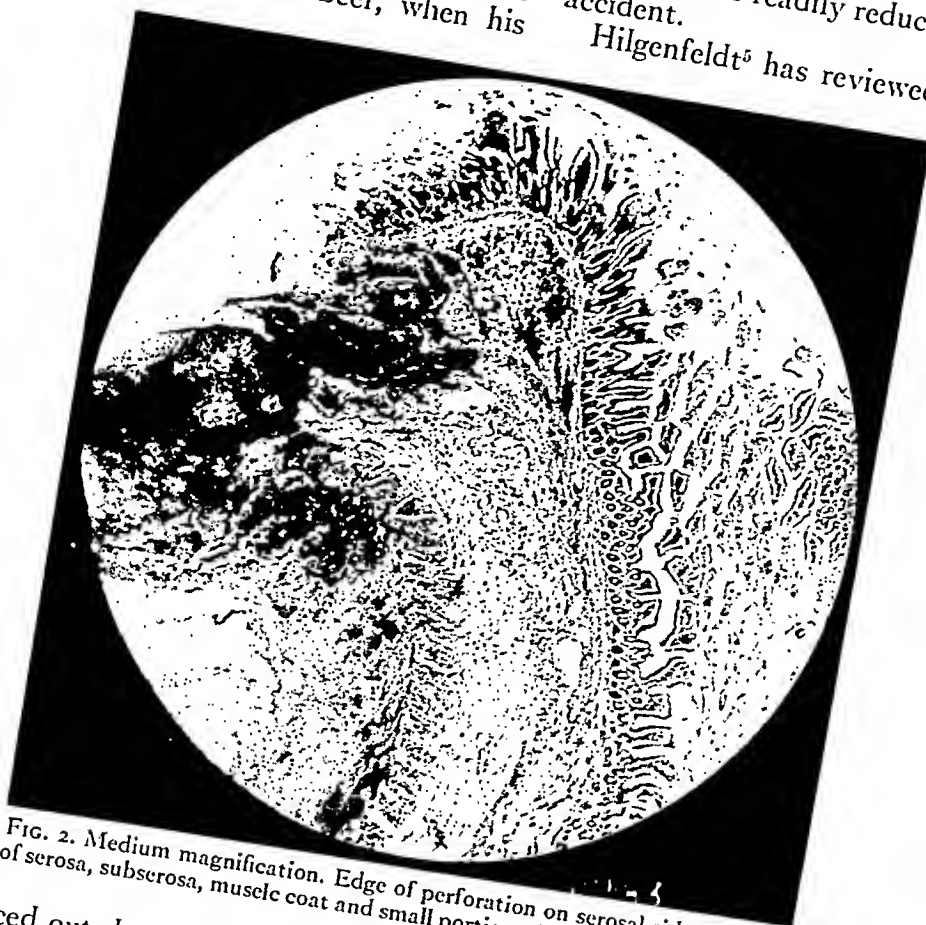


FIG. 2. Medium magnification. Edge of perforation on serosal side. Necrosis of serosa, subserosa, muscle coat and small portion of submucosa and mucosa.

hernia was forced out despite a truss, and was immediately reduced. Operation disclosed a transverse tear 1 cm. long on the antimesenteric border of the ileum, with prolapse of mucosa. The forceful protrusion and reduction of the hernia were a definite part of the clinical history.

By contrast, cases such as those reported by Wiedhopf,<sup>2</sup> Siegmund,<sup>3</sup> and Breuning,<sup>4</sup> illustrate rupture of intestine with peritonitis following heavy lifting strain in individuals with hernias, without the definite history of forceful protrusion or transient incarceration. Even if such protrusion most likely occurred, it apparently was so rapid and transitory that it had not attracted the attention of the sufferer sufficiently to be emphasized in his history. On examination the hernia could be pro-

covering the type of accident represented by rupture of intestine from excessive muscular effort in individuals with hernias. Recently, Aird<sup>6</sup> has reported four cases in which the accident occurred as the result of violence inflicted on the abdomen, or of sudden muscular strain, without direct contusion, or forceful reduction of the hernia itself.

Where forceful protrusion alone has been responsible for the accident, the explanation put forth by Bunge<sup>7</sup> has usually been accepted as the most plausible. Bunge demonstrated that if an inflated balloon is placed in the barrel of a syringe, and the nozzle is closed with the finger, increasing the pressure upon the plunger will not cause the balloon to rupture. If, however, the occluding finger is removed from the



nozzle, the balloon will be forced towards the nozzle opening, and will rupture.

In the abdomen, the situation is similar,

would explain some of these cases as being due to an overstretching of a loop of intestine, fixed at one end at the ileocecal

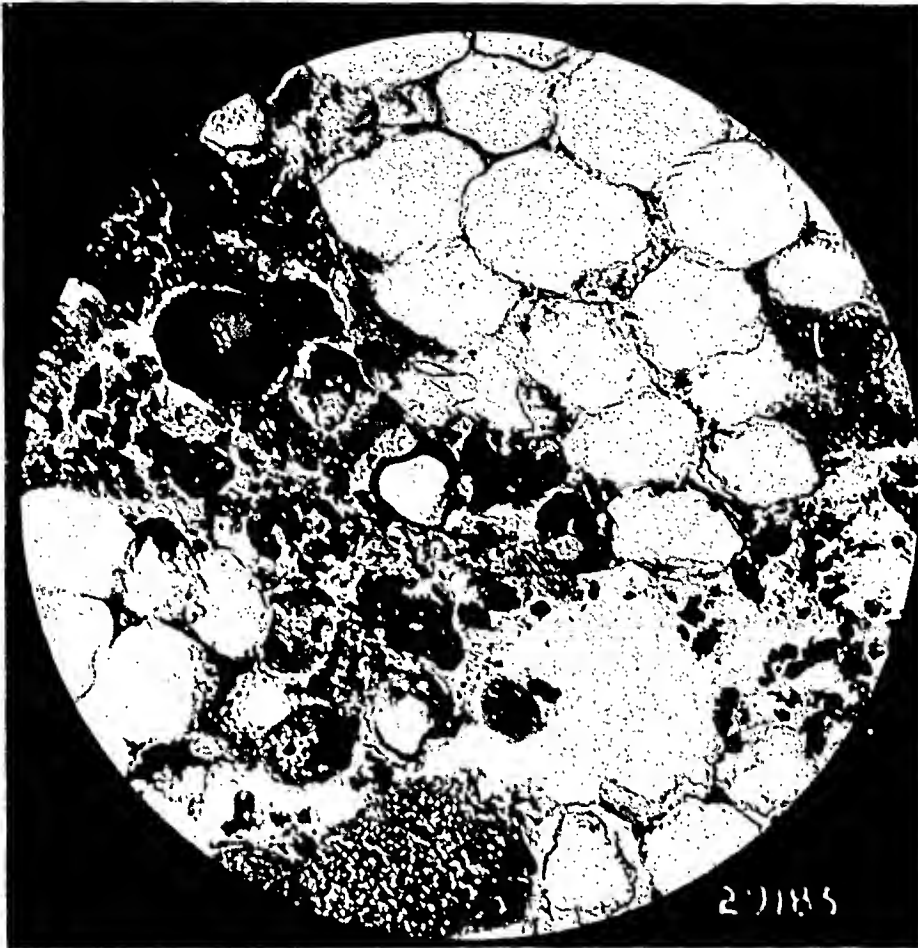


FIG. 3. High magnification. Inflammation around intestinal contents in the fat tissue of the mesentery.

when violent contraction of the abdominal wall muscles occurs. The increased intra-abdominal pressure produces a corresponding increase in the intra-intestinal pressure. This intra-intestinal pressure is counterbalanced in all directions, except where a loop of gut overlies a hernial ring. Here, there being no counterbalancing force, the loop of gut is forced into the sac, and the bursting action continuing, rupture of the intestine takes place. With the cessation of the pressure, the loop spontaneously slips back into the peritoneal cavity, and the leakage quickly sets up a diffuse peritonitis.

Aird, in analyzing the mechanism of rupture in the abdominal compression type of case, believes that the Bunge theory cannot be unqualifiedly accepted. He

or duodenojejunal junctions, and gripped at the other by a contraction of the abdominal muscles around the hernial orifice.

By way of illustration, in one of Aird's cases, the rupture of intestine occurred when a man of 52, on descending from a street car, slipped and saved himself from falling by sudden violent hyperextension of his trunk. Intense pain in the abdomen and in a right inguinal hernia, which had been readily reducible for years, with progressive evidences of generalized peritonitis, led to operation. A transverse tear of gut was found 7 inches below the duodenojejunal junction. Thus, hyperextension of the spine and contraction of the abdominal musculature presumably caused a distraction of the points of fixation of the

intestine, namely the duodenojejunal angle and the inguinal hernia.

In the cases where forceful reduction or contusion of a transiently incarcerated hernia produces rupture of bowel, the mechanism is slightly different, but depends in the main on the production of a bursting force. If gut is temporarily trapped in a hernial sac, the contained fluid and gas have no escape except through the neck of the sac. If this neck is narrow, and surrounded by fairly rigid structures, as is the case in femoral hernia, such a result from a continued compressive force applied to the hernia, as in prolonged and forceful taxis or direct contusion by an outside blunt force. The bursting mechanism is similar to the rupturing of a toy balloon by direct compression suddenly and forcibly applied.

Sänger,<sup>8</sup> in 1910, reported on forty cases of bowel rupture from forceful taxis of hernias, with supervening peritonitis from intraperitoneal replacement of injured bowel. These forty cases included five of his own and altogether represented the total number of reported cases dating back to 1844. In this series, the frequency of the accident increased with advancing age groups; cases in women were more frequent than in men (the reverse of the relationship in the cases due to excessive muscular effort); femoral hernias were more frequently involved than inguinal cases; and the duration of the hernias varied from three days to seventy-five years.

Since Sängers review, isolated cases of this taxis rupture type have been reported in the German literature by Gutzeit,<sup>9</sup> Hilgenreiner,<sup>10</sup> Schmidt,<sup>11</sup> and Krauss.<sup>12</sup>

In the French literature, somewhat over a dozen cases have been reported by Brocq,<sup>13</sup> Huet,<sup>14</sup> de la Marniere,<sup>15</sup> Rouseau,<sup>16</sup> and Jouillard.<sup>17</sup> Most of the cases reported by these French authors deal with rupture of bowel following contusion by external blunt force, mild or severe,

applied directly to the hernia, or mediately through the pad of a truss, with generalized peritonitis ensuing from replacement of the injured bowel into the peritoneal cavity.

In the English and American literature a few isolated cases of this type of injury have been reported. Moir<sup>18</sup> described a case of self-inflicted rupture of small intestine caused by self reduction of a non-strangulated inguinal hernia.\*

It has been implied by some authors that rupture of intestine from taxis or contusion of hernia has occurred at a site in the intestinal wall which has become weakened from repeated previous incarcerations, with loss of elasticity from repeated inflammatory reactions and fibrous replacement. That this does not hold in all cases is evidenced by the fact that the accident has occurred in cases of hernia of short duration, and that microscopic examination of such intestine has often failed to reveal any abnormality in its structure. Furthermore, the same loop is not always present in a hernial sac, as is shown by the reappearance of the hernia on coughing or straining, while the injured bowel is lying within the peritoneal cavity at a distance from the hernial ring. The same argument applies to the injurious effect on the bowel wall of the wearing of a truss. In some cases, no truss had ever been worn.

Perforations occur either at the summit of the free border of the intestine, or at the mesenteric attachment. The determination of the location appears to depend on the manner in which the force is applied to the trapped intestinal loop. If applied laterally, the bursting force is likely to find vent at the apex of the loop; if applied over the summit, the rent is likely to occur at the mesenteric attachment. Drummond<sup>19</sup> has called attention to the likelihood of an intramesenteric rupture of small intestine

\* Wilensky and Kauffman (*Ann. Surg.*, 106: 373, 1937) report a case of intestinal rupture following a heavy lifting strain in a man who had had an inguinal hernia for four years previously, apparently well controlled by a truss. Their article provides abstracts of forty-two cases of this type of injury that have appeared in the literature.

being due to the weakness in the bowel musculature at the points where blood vessels perforate the gut wall to reach the submucosa and mucosa, and the absence of peritoneal support at this site.

In Sanger's collection of forty cases of taxis rupture of intestine, twenty-two were operated on, with ten recoveries, yielding a total mortality of 75 per cent and an operative mortality of 55 per cent. The time interval between the occurrence of the accident and surgical intervention stood out as the most important factor determining recovery. Similarly, in Brocq's collection of fourteen cases of intestinal rupture due to direct contusion of hernia, thirteen were operated on, with three recoveries in cases that had not gone over ten hours before surgical intervention.

#### CONCLUSION

A case report is presented to illustrate the danger of rupture of intestine in the application of force to a hernia, whether during protrusion as result of undue muscular strain, or during reduction as result of forceful taxis or contusion.

Attention is directed to this rare, but nevertheless likely type of accident to which every possessor of a hernia is liable, and a strong argument is thus provided for the early repair of a hernia, unless a major contraindication to operation exists.

The mechanism of bowel rupture in this type of case under varying circumstances is briefly discussed.

The need for early diagnosis and intra-abdominal surgical intervention is emphasized, since a favorable outcome, other factors being equal, can only be expected in those cases in which operation is promptly performed.

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# LEIOMYOMA OF THE PROSTATE GLAND

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IN spite of the reports in the literature of eighteen cases of leiomyoma of the prostate, there is still some question 1924; Bugbee in 1926; Vignolo, Rubritus in 1928; Wolman in 1931; Hinman and Sullivan (2) in 1931; Deuticke in 1932; Dial

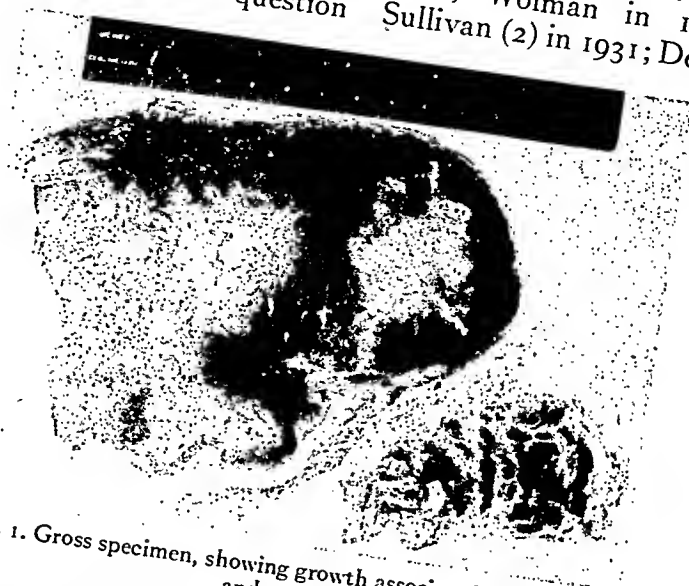


FIG. 1. Gross specimen, showing growth associated with bladder and rectum.

concerning the true nature and origin of these neoplasms. Tumors of this character may arise from any of the fibromuscular tissues found in this region, i.e., prostate, bladder, rectal wall, and the retroperitoneal tissues. In 1920, I reported the history of a patient afflicted with a tumor of this nature arising from the retroperitoneal tissue behind the rectum. However, it would seem from the embryologic development of the prostate and the amount of muscle tissue found normally in it, that a leiomyoma occurring in this location would more likely arise from the prostate than from the other tissues mentioned. Again an entity of diffuse muscular hyperplasia may occur in the prostate revealing a microscopic picture very similar to that of leiomyoma. Such a case was reported by me in 1930. Occasional cases of leiomyoma of the prostate have been reported—by Lebec in 1876; Damski in

and Halpert (3) in 1933; Frank Patch and L. J. Rhea in 1935; Mitchell and Blaisdell, 1936; R. H. Akin, 1936; Koenig, 1936; L. H. Baretz 1936; and Mimpriss in 1936. The following case is added to the above:

M. S., a white male, about sixty years of age, was admitted to the hospital on November 6, 1934. He stated that about six weeks before he became constipated and began to use cathartics. At first these gave relief, but the constipation had gradually become worse and during the past seven days he had had no bowel movement. About three months before he began to suffer with nocturia. Six weeks before he noticed a large amount of blood in the urine but there had been no hematuria since then.

Physical examination revealed a fairly well preserved adult male apparently not suffering any pain. Examination of the heart and lungs was negative. The abdomen was not distended, but the bladder was palpable well above the pubis. To the right of the bladder there was a

large firm mass apparently filling the pelvis. Proctoscopic examination revealed the mucosa of the rectum to be normal. The systolic blood pressure was 220, the diastolic 90. The hemoglobin was 87 per cent, R. B. C. 4,590,000, W.B.C. 10,500. The urine showed a trace of albumin, an occasional white blood cell and a few red blood cells.

A colostomy was performed, but there was no attempt to ascertain the nature of the mass. Following the operation the patient became much worse and passed away a few days later.

At autopsy the mass felt in the lower abdomen was found to arise from the base of the bladder, almost entirely replacing the prostate. It extended well up behind the posterior bladder wall and nearly surrounded the rectum. It weighed 1450 Gm.

Of the eighteen cases previously reported, thirteen had chiefly urinary symptoms, four primarily rectal or perineal manifestations, and one had painful erections as a chief symptom. The case reported is unique in the fact that the obstipation had progressed to the point where there had been no bowel movement for a week

and surrounding the rectum; the other, sometimes pedunculated, may be closely associated with the urethra and bladder

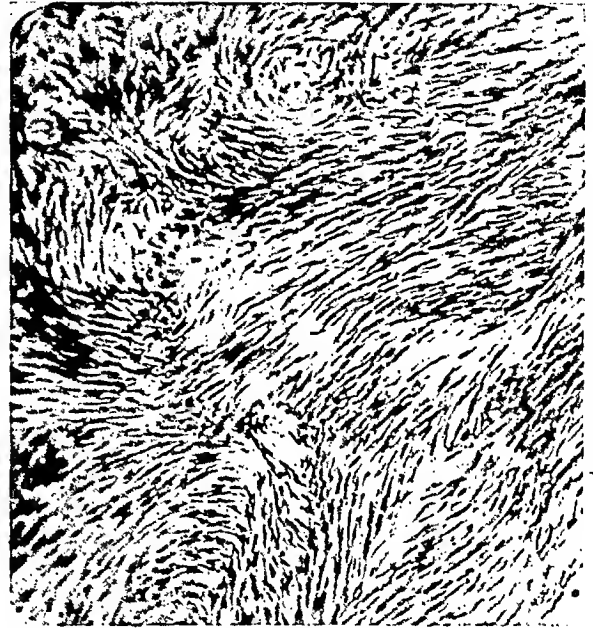


FIG. 2. Photomicrograph of growth, low power.

and cause obstruction of the bladder or ejaculatory ducts, as in the case reported by Akin, or the pedunculated tumor may extend into the surrounding prostatic



FIG. 3. Photomicrograph, low power, showing marginal area of tumor to capsule.

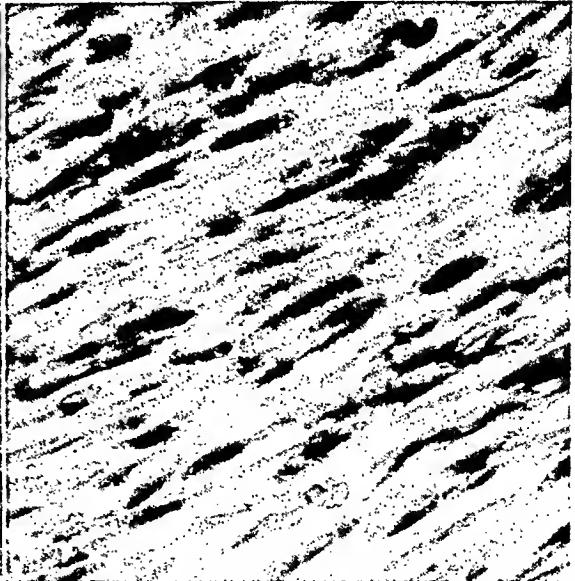


FIG. 4. Photomicrograph of growth, high power.

and the surgeon in charge considered a colostomy indicated to relieve it.

Two types of these tumors appear to occur: one, massive in size, involving and obscuring the prostate and filling the pelvis

tissue as in one of the cases reported by Hinman and Sullivan. The very small multiple myomatous nodules situated in glandular or adenomatous areas of the prostate have not been considered. The

case herein reported is of the massive type.

#### SUMMARY

A report is given of a patient afflicted with massive leiomyoma of the prostate, causing obstipation. A brief review of the literature and pathologic studies are included.

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IN the city of Bologna, Italy, there lives an orthopedic surgeon by the name of Putti. He has educated the mothers of that vicinity [where congenital dislocation of the hip is very common] to look for the deformity and find it long before the child begins to walk. His results are reported the best in the world.  
From—"From Head to Foot" by Armitage Whitman (Farrar & Rinehart).

# NEW INSTRUMENTS

## A NEUROSURGICAL SUCTION-IRRIGATOR

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THE problem of maintaining a clearly visible operative field in neurosurgery is of vital importance, not only because of the methods and time necessary to obtain it, but often because of the relative inaccessibility of the operative area and the nature of the work. The methods commonly used to establish and maintain a blood-free field usually consist of lavage with normal saline solution at body temperature, aspiration through moist cotton pledgets, or a combination of both lavage and aspiration. There must be as small an expenditure of time and effort as possible, for, until the field is clear, the operation is halted.

The ordinary irrigation is accomplished by the use of rubber bulb syringes, several of which must be kept filled in an open container of warm saline, these being passed to the surgeons when needed. The open reservoir with its inconstant temperature, the time and effort wasted in the passing and handling of the syringes, together with the degree of efficiency of the stream, made it desirable to eliminate these elements in the interest of better technique.

Cognizant of these difficulties, Fay<sup>1</sup> introduced the closed irrigation system and, realizing the advantages of having the suction and aspiration units combined, presented a double-barrelled, pistol-gripped instrument to accomplish this end.

The instrument presented here is a simplified suction-irrigator which conforms more in size, shape, simplicity, and maneuverability with the suction tubes commonly

used, but possesses the further advantage of combination with the irrigation unit. (Figs. 1 and 2.)

The suction unit (B) is parallel with the irrigation tube (A) until the point of common attachment, the rotary valve (C). The discharge tube (D) is common to both systems, the choice of which is determined by the position of the thumb lever (E). The irrigator is effective with the lever pushed forward; the aspirator, with the lever drawn back. The neutral position pictured closes both systems. The discharge tube may be of mouldable metal and removable to accommodate tips of different sizes.

Normal saline solution at 100°F. is brought to the instrument through sterile tubing from a one liter infusion flask whose height determines the size and velocity of the irrigating stream. In contrast to the stream produced by a bulb syringe, i.e., an irregular flow of considerable but rapidly decreasing volume, velocity, and pressure, and followed usually by a certain amount of frothing from the air invariably trapped in the bulb, this instrument gives a continuous stream of constant pressure and flow with no vision-obscuring bubbles. The loss of heat from such a closed system and the possibility of contamination is considerably less than when the open reservoir is employed.

An annoying feature of the usual suction tube is the frequency of blockage due either to aspiration of too large a clot, piece of tissue, débris, etc., or more frequently by the accumulation of material behind the



small droplets of bloody fluid, dried by the continued passage of air over them within the tube. In this instrument such difficulties are obviated by the ease with which the tube is washed after using. A rapid forward and backward movement of the thumb lever will deliver water into the tube

instrument to be most satisfactory when dealing with the problem of the clean operative field, and it is possible, that, with

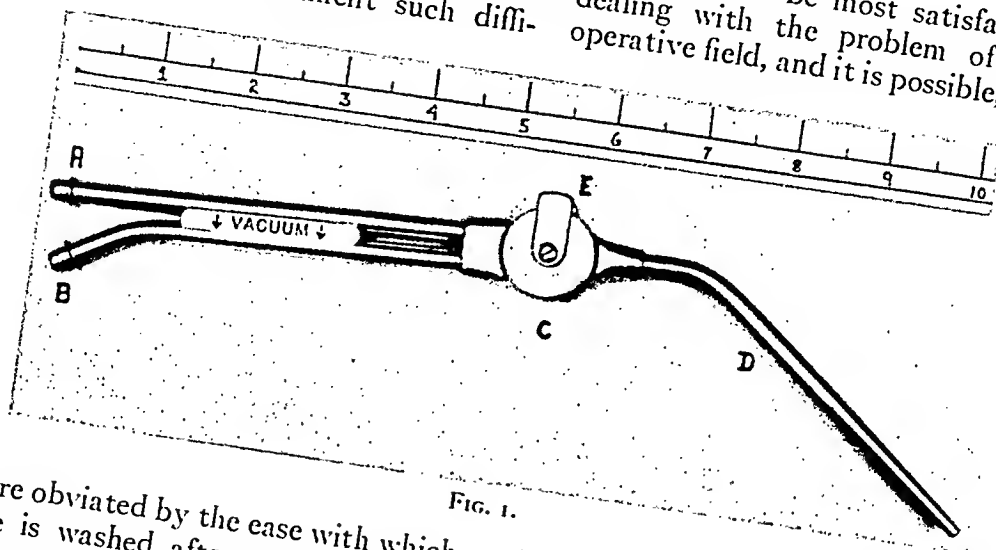


FIG. 1.

minor changes in size and construction, it may be used in other branches of surgery. We acknowledge with appreciation the efforts of Mr. V. B. Seitz, of the Technical

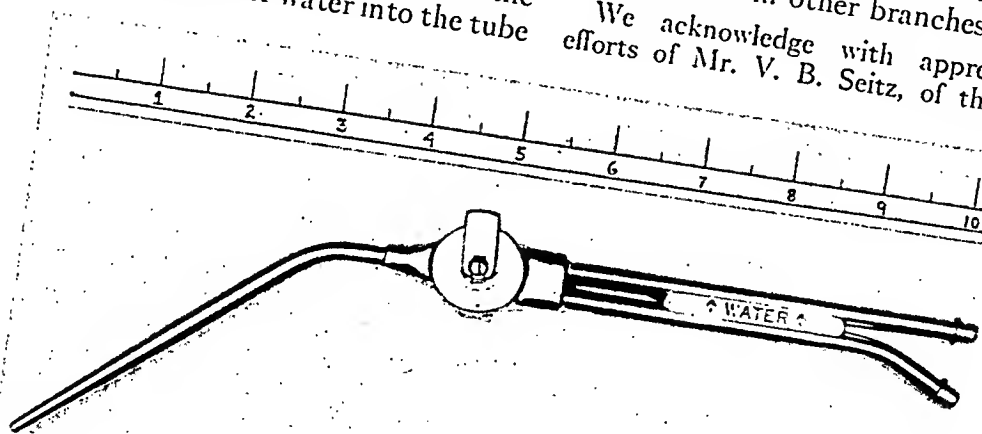


FIG. 2.

and subsequently aspirate the potentially obstructive material. The tube may be washed with the expenditure of practically no time or effort and the troublesome blocking is not encountered.

While it is not beyond criticism, members of the Neurosurgical Department of the Cleveland Clinic have found this

Engineering Department in the production of the final working model.\*

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\*This instrument is manufactured by the Max Wocher & Son Co., Cincinnati.

# A DEVICE TO APPROXIMATE THE EDGES OF GAPING WOUNDS

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AND

F. M. AL AKL, M.D.

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SEVERAL years ago, we came to realize definitely that the foreign body inserted into the peritoneal cavity in order to drain out exudate, actually drains, not the general peritoneal cavity, but only the sinus tract which the drain's irritating presence creates. Regardless of the composition or texture of the drain, nature always seems to detect the foreign body and immediately sets itself to the task of isolating it by depositing fibrin around it in an effort to extrude it. Such observations led to the conclusion that in generalized peritonitis, nothing is gained by inserting a drain among the intestinal loops, or between the intestines and the abdominal wall, while a tremendous amount of damage often results. The fibrinous exudate deposited by nature to wall off the intruding drain forms adhesions between the loops of bowel involved. As a result post-operative distention and intestinal obstruction occurred more frequently, while the line of incision, weakened by the aperture through which the drain protrudes, is predisposed to eventration and subsequently to incisional herniae.

Our results have justified the discard of intraperitoneal drainage and the adoption of the routine of closing the abdominal wall completely after removing the cause of pathology and aspirating the excess of free exudate in the cavity.

While in the beginning we closed all the layers including the skin, the discovery that in many cases the wound became infected prompted us simply to suture the peritoneum, muscle, and fasciae and to leave the skin and subcutaneous fat wide open by gentle packing with iodoform gauze. With the adoption of the new routine, we became confronted with the problem of healing these open wounds

without undue prolongation of morbidity and discomfort to the patient. The routine developed is to dress the wound forty-eight hours after operation and irrigate it with Dakin's solution by means of a bulb syringe. After thorough cleansing of the wound, the raw surface is rigidly inspected and the thickened discharge is swabbed away while loose knots of catgut or fragments of tissue are picked up. Another irrigation follows and the wound is packed and dressed. This procedure is repeated daily and the wound observed from day to day. In the beginning, we laid great stress upon daily bacterial counts, but their misleading import prompted us to depend entirely upon simple observation. Daily notations are made of the character of the discharge, the redness and edema of the exposed tissue and the adjoining normal skin, and the character of the granulations. In three to four days, one is able to tell if infection has set in or not. If the wound becomes infected, the Dakin irrigations are continued until the granulations and the adjoining skin becomes healthy and the discharge has changed from purulent to thin and mucoid.

While secondary suture of the wound at this stage is in order, such an operation is not at all welcomed by the patient. Bringing the wound together with strips of adhesive has proved unsatisfactory. The serous discharge accumulated under the adhesive and was difficult to clean, while the strips themselves often loosened and became useless especially when wet with alcohol while the wound was being cleansed. Moreover, approximation with adhesive strips was often attended by puckering and improper coaptation. In order to surmount these difficulties, we made the illustrated bridge by soldering to each end of a curved

bar a metal buckle. (Fig. 1.) A quantity of these bars was made in two sizes in the workshop of the Kings County Hospital. and absorb any serous discharge. (Fig. 4.) In this manner the dressing of the wound was greatly simplified as the bridges

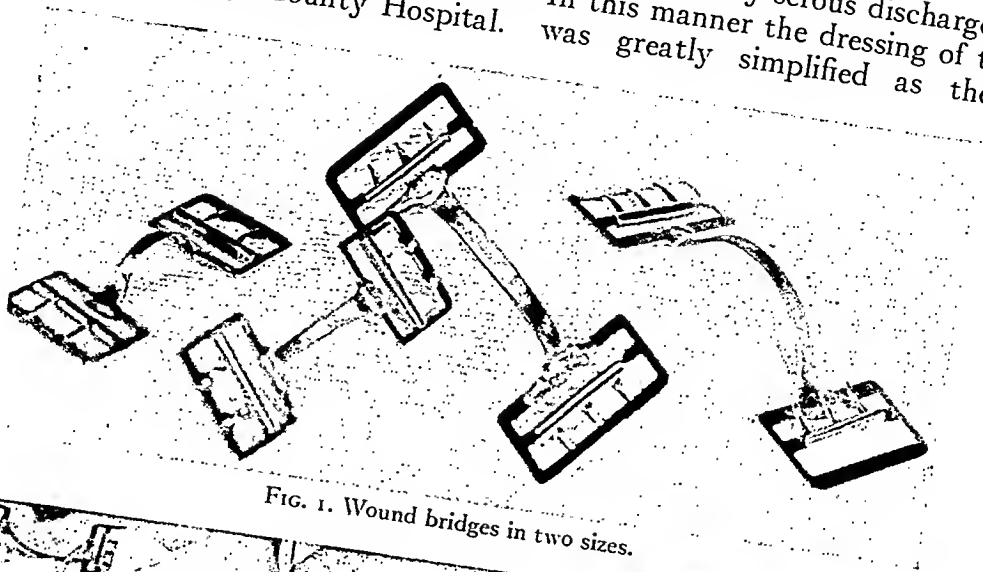


FIG. 1. Wound bridges in two sizes.

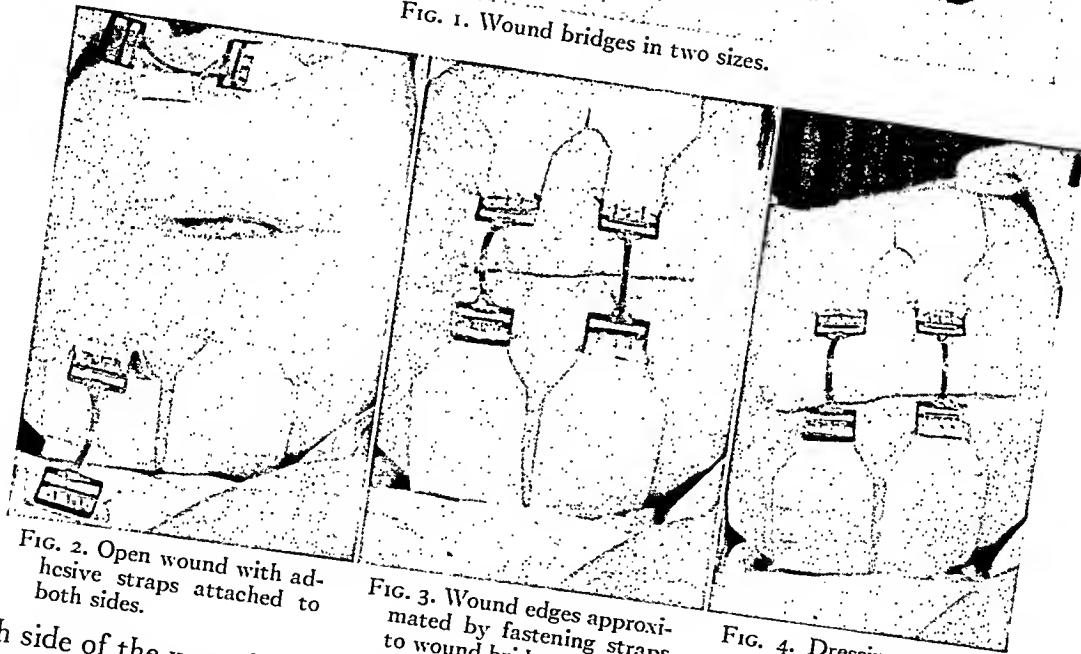


FIG. 2. Open wound with adhesive straps attached to both sides.

FIG. 3. Wound edges approximated by fastening straps to wound bridges.

FIG. 4. Dressing applied by passing a folded 4 by 4 inch underneath bridge arch.

On each side of the wound, straps of adhesive plaster were attached to the skin and the portion towards the wound was folded upon itself so as to obliterate the sticky surface and form a ribbon. (Fig. 2.) The bridges were sterilized by boiling, the ribbons threaded through the buckles on each side and pulled out until the edges of the wound came firmly together. (Fig. 3.) Strips of dry gauze were then placed underneath the arches to keep the wound clean

remained in position while the gauze underneath the arches was changed every few days.

In elderly patients, where healing is slow and sutures are left for more than a week, these bridges have proved invaluable, for as the sutures begin to cut through, the application of the bridges relieves tension on the sutures and helps to maintain the edges of the wound together.

S P E C I A L   A R T I C L E

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# Carcinoma of the Rectum and Sigmoid

BY

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# CARCINOMA OF THE RECTUM AND SIGMOID

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THIS report is based on a series of 111 consecutive cases of cancer of the anus, rectum and sigmoid, treated personally. It includes eighty-two in which the involved bowel was resected, twenty-six which were treated only palliatively, and three in which local excisions were performed. (Table 1.) We have recently seen in follow-up the first case of this series operated upon twelve years ago by a two-stage abdominoperineal resection.

TABLE 1  
OPERATIVE PROCEDURE

Resections.....	82
Simple colostomies.....	26
Local excisions.....	3
	<hr/> 111

## PATHOLOGY

Cancers of this region comprise three-fourths of the neoplasms of the large bowel. Approximately 97 per cent of these growths are malignant adenomas or adenocarcinomas. (Figs. 1, 2, 3 and 4.) Less than 1 per cent are carcinomas simplex (Fig. 5), colloid cancers (Fig. 6), or the rare melanomas. Two per cent are squamous cell growths (Fig. 7), and these are almost invariably located at the anus.

Probably both the malignant adenomas and the adenocarcinomas are degeneration forms of benign adenomas. That this transformation occurs is suggested by the following facts: (1) Occasionally a polyp is removed which on histologic examination shows a definite transition from a nonmalignant to a malignant tumor. (Fig. 8.) (2) The distribution of cancer—eight times as frequent in the sigmoid and rectum as in other portions of the bowel—corresponds closely to the distribution of polyps. (Fig. 9.) (4) Frequently polyps appear subsequent to, and near, the site of resection for cancer of the rectum. (5) Individuals occasionally are seen with one carcinoma in the rectum and another in the sigmoid. (Case 52 in this series.)

We have been taught that cancer of the rectum is a cauliflower or ulcer, that it usually metastasizes very slowly, and that most of the growths with glandular involvement are excavating lesions with

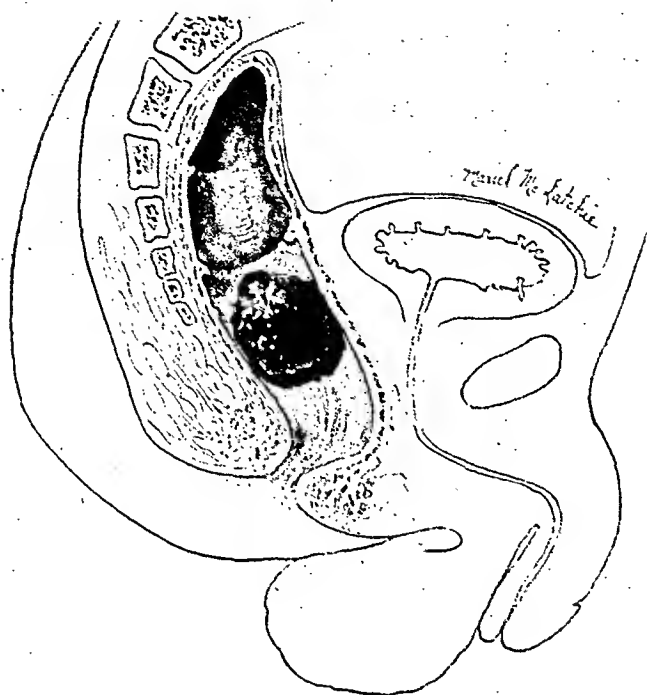


FIG. 1. Papillomatous malignant adenoma.

a tendency to invade the muscularis. The nodes involved usually are those nearest the point of direct extension, and apparently there is no relation between the size of the growth and the extent of regional involvement. Local extension, in fact, renders a lesion inoperable more often than does metastasis. However, we are not apt to be impressed with the *small, soft, superficial* polyp. But this seemingly benign tumor not only may be a cancer, but may already have metastasized.<sup>4</sup>

Recently we saw in follow-up an individual (Case 56 in this series) on whom we operated four years ago, whose summarized case history illustrates the point just made. He had noticed slight bloody staining of stool twice during the three months previous to entry. He, however, had observed *no* rectal pain, tenesmus, mucus, or frequent stools. Nevertheless, 7 cm. above the anus, was a small soft tumor which apparently did not penetrate beneath the submucosa. It was removed widely by electrodesiccation. (Fig. 10.) The pathologic report read: "A soft mass, measuring  $2 \times 1 \times 1$  cm.; diagnosis—adenocarcinoma, Grade II." (Fig. 11.) The patient was

persuaded to have a radical resection. The rectum after removal showed no trace of the primary tumor (Fig. 12), but was associated with two small pararectal nodes containing metastases. (Figs. 13



FIG. 2. Papillomatous malignant adenoma.

and 14.) It is therefore not safe to depend on the criteria of size, soft consistency, and mobility in estimating the malignancy of a rectal tumor. This case history serves to emphasize the point made by Miles and others, that if a diagnosis of adenocarcinoma of the rectum is confirmed, and if the patient's condition warrants it, nothing less than an excision, having as its upper limit a wide margin of intestine above the growth and including the glands of the mesosigmoid, is justified.

A negative biopsy is dangerous. One section of a tumor may appear benign under the microscope, whereas if another section were examined a report of cancer would be returned. (Fig. 8.) One individual (Case 17 in this series) had a negative biopsy a year and



again six months before she finally entered the hospital. By that time she had a huge growth of borderline operability.

A biopsy may give a false idea of the degree of malignancy. This

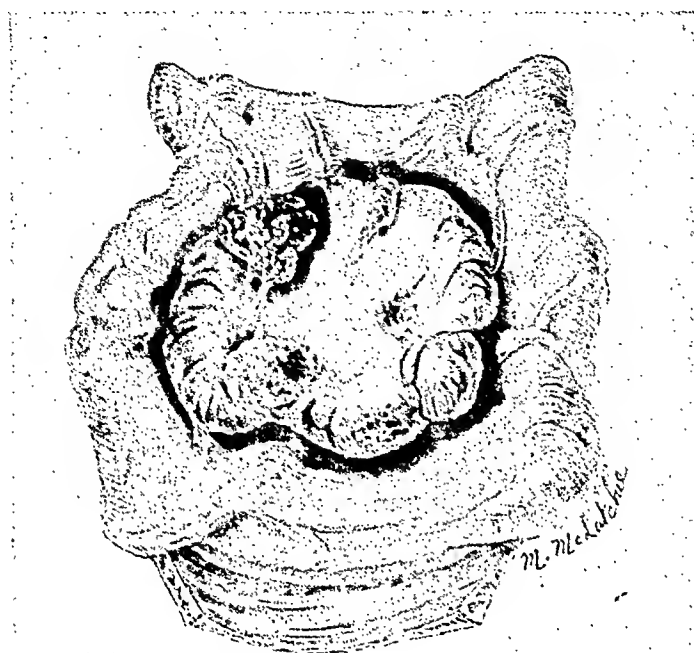


FIG. 3. Adenocarcinoma.

is illustrated by Case 99. The biopsy specimen showed a malignant adenoma (Fig. 15), while the tumor in the resected rectum was reported as an adenocarcinoma. (Fig. 16.)

If one feels that the tumor in question probably is benign, it is better, whenever possible, to excise the entire lesion with a good margin of healthy tissue and submit the whole for histologic examination. In the larger tumors and in those high in the rectum this is sometimes difficult to accomplish, but for the growths that can be prolapsed downward (Fig. 17), the technique of excision which we employ is shown. (Fig. 18 and 19.) With the tumors clinically benign and too large to excise locally, one must either resect the rectum or employ electrocoagulation. If a small area of malignancy should be present and not discovered, as is quite possible, by this latter technique, the danger of metastases has not, of course, been eliminated.

#### AGE

The age factor has only this importance: that while the highest incidence is in the same decade of life as is cancer elsewhere in the

body—the fifth and sixth—it must be remembered that rectal cancer also may appear in youth. Some years ago we saw an inoperable carcinoma of the rectum in a girl of 12. In a series reported by us in



FIG. 4. Adenocarcinoma.

1933,<sup>2</sup> 0.5 per cent of the patients were under the age of 20 and 5 per cent between 20 and 25. In the present series, the oldest was 82 and the youngest 22.

## MANAGEMENT

Though there has been definite progress in the management of this disease, it is obvious that the percentage of cures *will only be*

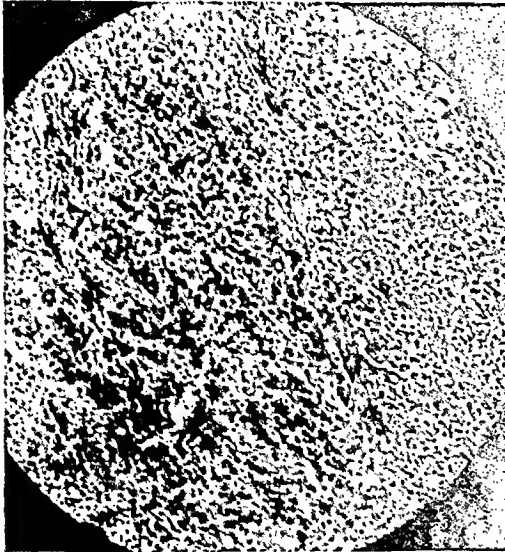


FIG. 5. Carcinoma simplex.

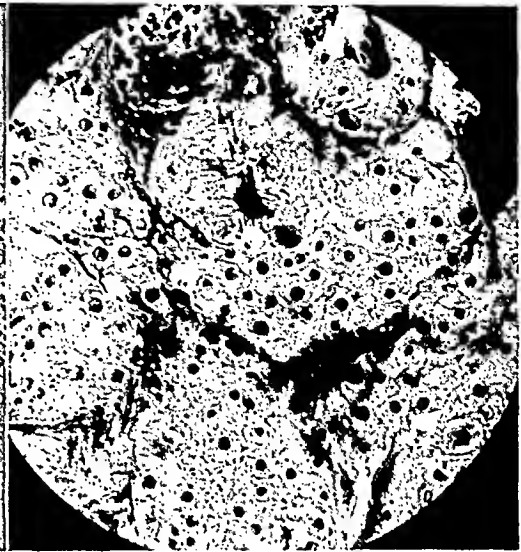


FIG. 6. Mucinous carcinoma.

*increased* in proportion to emphasis on two factors: (a) earlier diagnosis; and (b) improvement in therapy.

## EARLY DIAGNOSIS

The ideal situation is one in which the growth is discovered before any symptoms develop. With increasing pressure on both physicians and laymen via medical literature and public education, these very early cases are beginning to appear.

During the past few years we have had under our care three individuals with rectal growths who had no lower bowel symptoms whatsoever, and a fourth who sought aid solely because of pruritus ani. The first was an old man with an arthritis of the right knee. Routine digital examination disclosed a rectal carcinoma about 1.5 cm. in diameter. The second was a woman who complained of a lumbar backache. X-rays revealed no evidence of a metastatic malignancy. Routine digital examination revealed a cancer of the rectum about the size of that in the first case. The third sought aid because of a pilonidal sinus. He also had a rectal cancer less than 1 cm. in diameter. The fourth came in with a friend who had cancer of the rectum; he desired advice regarding his itching. He had a carcinoma half encircling the rectum. (Fig. 20.)

As we become more cancer-of-the-rectum-conscious, an increasing number of what we now call atypical cases will be discovered. It is conceivable that some individuals with very early malignant

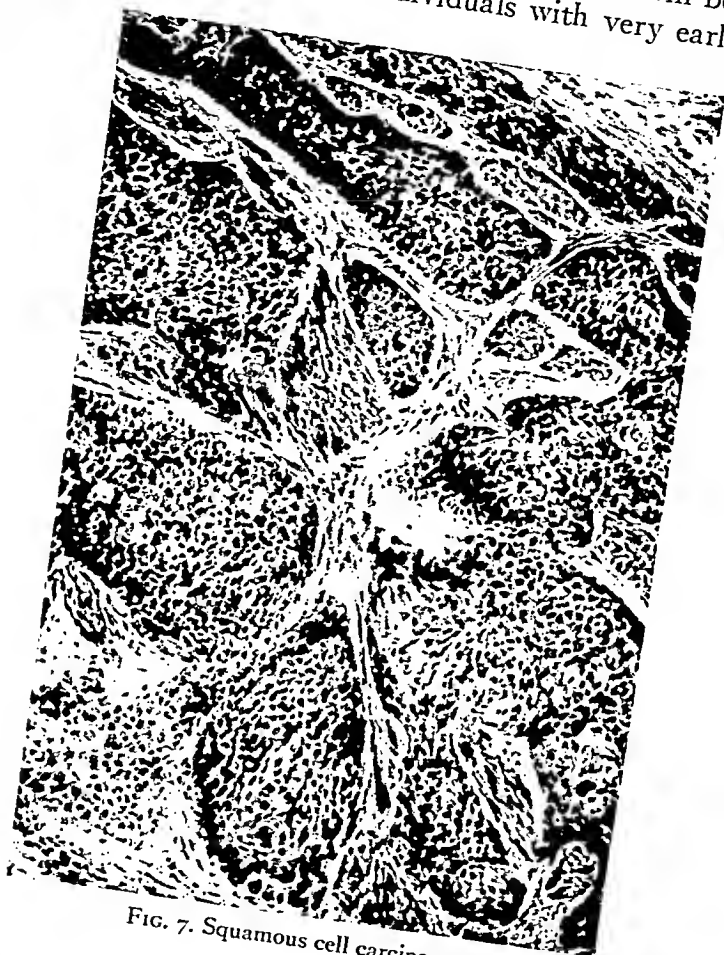


FIG. 7. Squamous cell carcinoma.

adenomas may be cured by wide local excision of the growth, but in dealing with an adenocarcinoma it is necessary to resect the rectum no matter how small the neoplasm. We trust the time will come when every patient will demand a routine rectal examination, be he afflicted with migraine, tonsillitis, or dermatitis venenata. A periodic health check-up should always include such an examination.

Unfortunately, most large series contain a high percentage of late cases. Although resection could be accomplished in three-fourths of the present series, 63 per cent of the group came in with symptoms of more than four months' duration. (Table II.)

This is further emphasized by Table III showing the circumferential involvement.



FIG. 8. Biopsy specimen. Adenocarcinoma at left of photomicrograph, benign adenoma at right.



FIG. 9. Nest of adenomatous polyps with cancer at either end of specimen. (Staff case, Palmer Memorial Hospital, courtesy of Dr. Richard Sweet.)

# 490 SHEDDEN—CARCINOMA OF RECTUM AND SIGMOID

TABLE II  
DURATION OF SYMPTOMS BEFORE ADMISSION\*

	Cases
Less than 1 month.....	3
1 to 2 months.....	14
3 to 4 months.....	20
5 to 6 months.....	20
7 to 12 months.....	34
Over 12 months.....	16
Indefinite.....	4
Total.....	111

\* 63 per cent delayed four months or more.

TABLE III  
CIRCUMFERENTIAL INVOLVEMENT ON ADMISSION TO HOSPITAL

	Cases
Annular.....	37
One-half of circumference.....	2
Three-fourths of circumference.....	2
	—
	41

It is probable that lack of pain (Table iv) frequently accounted

TABLE IV  
SYMPTOMS FIRST NOTICED BY PATIENT

	Cases
Rectal pain alone.....	6
Rectal pain and other symptoms.....	5
	—
	11

for the long interval between the onset of symptoms and the first visit to a physician (Table v), yet in several instances the delay was due to the fact that the physician in charge was misled (Table vi) by the absence of such textbook symptoms as: (1) definite changes in bowel habit; (2) pronounced bleeding; or (3) tenesmus.

TABLE V  
DELAY BETWEEN ONSET OF SYMPTOMS AND CONSULTATION WITH DOCTOR\*

	Cases
Less than 1 month.....	5
1 to 2 months.....	18
3 to 4 months.....	12
5 to 6 months.....	13
7 to 12 months.....	9
Slight delay.....	11
No mention.....	43

\* 41 per cent delayed two months or more.

TABLE VI  
DELAY BETWEEN CONSULTATION WITH DOCTOR AND ENTRANCE TO HOSPITAL \*

	Cases
Less than 1 month.....	23
1 to 2 months.....	11
3 to 4 months.....	14
5 to 6 months.....	14
7 to 12 months.....	10
12 months.....	2
Over 12 months.....	4
No mention.....	33
Total.....	111

\* 45 per cent delayed two months or more.

We now realize that these symptoms are descriptive in most cases of a carcinoma in its *late stages*. If the bleeding is coming from a cancer of the rectum, it means that the growth has advanced until ulceration has invaded blood vessels, and consequently has existed for a considerable period. Not only must we be alert to detect the slightest change in bowel habit, but we must also remember that a neoplasm of the lower bowel may be, and often is, present weeks and even months before the patient's attention is directed to his rectum.

1. *Obstruction.* Definite symptoms of intestinal obstruction will of course make for a prompt diagnosis, but when they are indefinite or mild we must be on our guard. They may entirely disappear after the use of mineral oil, and a dangerous delay may supervene. Six years ago, at the Massachusetts General Hospital, we were in charge of a woman who had had increased constipation over a period of six months, but with the oral use of an intestinal lubricant her bowels had again become regular. The appearance of mucoid discharge, slightly blood-tinged, made her seek aid, which was fortunate, for the constipation factor had not caused her any concern. She had an annular cancer of the sigmoid, which we resected. It had an extremely small lumen. (Fig. 21.) Thus, until a diagnosis has been made, it is obviously dangerous to give oil, no matter how mild or indefinite may be the symptoms even of partial obstruction.

2. *Bleeding.* In cases of mild bleeding, lack of adequate examination may invite disastrous delay, especially if the patient also has definite hemorrhoids. In this series, thirty-six cases had a diagnosis of hemorrhoids before entrance. The diagnosis in many instances was made by the patient, who thereupon treated himself with salves, etc. Unfortunately, however, in a considerable number of cases the patients' physicians were also led astray by the presence



of hemorrhoids, either actually present or suspected. (Tables VII and VIII.) Obviously, the only way to avoid such an error is to make a careful high digital examination in every instance of rectal bleeding,

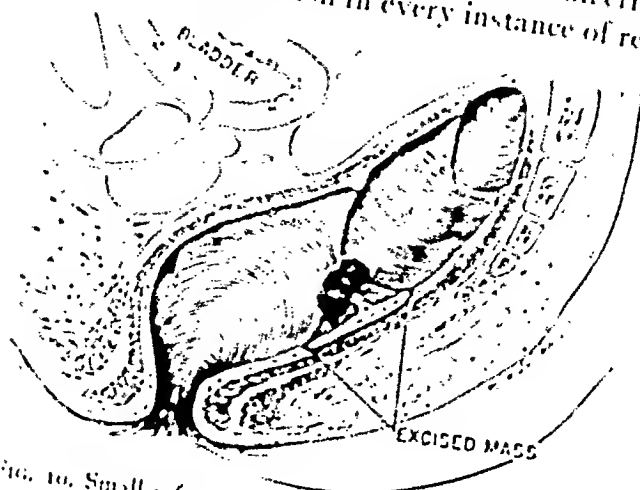


FIG. 10. Small soft tumor, clinically benign, but actually Grade II adenocarcinoma.

TABLE VII  
PREEXISTING RECTAL PATHOLOGY

Hemorrhoids  
Constipation  
Diarrhea

Cases  
37  
35  
23

whether or not hemorrhoids are present. The chance of error is diminished if sigmoidoscopic examination is added; and made even less if an x-ray examination with an opaque enema (Figs. 22 and 23) is employed. It is perhaps unnecessary to stress the fact here that a negative barium enema, like a negative biopsy, does not rule out cancer, and that the barium enema always should be preceded by a proctoscopy. If the latter is negative, the former is then urgently indicated.

*Examination of Rectum and Sigmoid.* The rectum and sigmoid comprise roughly 10 to 11 cm. of the large bowel, 5 cm. of which is above the peritoneal reflection of the cul-de-sac of Douglas. The average index finger is 8 cm. long, and usually can reach as high as the right valve of Houston. With the patient in Sims' position, and with a slight push, almost every carcinoma of the rectum can be felt. Not infrequently, with the patient in squatting position and straining, a rectosigmoidal growth can be palpated. This position is particularly useful with the type of growth that tends to prolapse. The diagnosis of cancer of the rectum and rectosigmoid can be

TABLE VIII  
ADVICE AND TREATMENT RECEIVED ELSEWHERE

	Cases
Referred to hospital without advice.....	26
Operation advised.....	18
Biopsy done.....	3
Colostomy before entrance.....	1
Medication, enemata, and massage.....	15
X-ray treatment given.....	2
X-ray treatment advised.....	1
Local excision done.....	1
Treatment for hemorrhoids.....	9
Treatment for hemorrhoids advised.....	2
Treatment for rectal ulcer.....	1
Suppositories and ointments.....	9
No mention.....	33
Total.....	111

made in 100 per cent of the cases, provided a careful digital and proctoscopic examination is made as a matter of routine.

#### IRRADIATION

Though definite progress has been made in radiation therapy, alone or in conjunction with surgery, the efficacy of this method is still relatively slight, save as a palliative procedure. Doses very close to the margin of tolerance of healthy tissue are required, and an overdose almost always results in necrosis and consequent sepsis.

Eight years ago we reviewed<sup>3</sup> 140 cases of rectal cancer treated by radium at the Huntington Memorial Hospital. Of these, no individual with proved cancer survived more than five years. Recently we reviewed<sup>3</sup> eighty more cases at the Palmer and Huntington Hospitals. No patient in this group lived free from disease for five years; but there was one three-year "cure"—an anal epidermoid carcinoma—and one four-year "cure"—a malignant adenoma. Of the eighty cases, fourteen were locally operable, but received irradiation because the age or general condition of the patient contraindicated surgery, or because operation was refused. One individual lived six years, but with disease. Of ten cases recurrent after radical operation, five were quite definitely improved after the irradiation. Electrocoagulation was added to the irradiation in four instances. In all four there was definite improvement.

The following methods of attack by irradiation seem worth discussing:

1. Intracavitary surface irradiation.
2. Intrarectal irradiation with needle or seeds.

3. Barrage by open operation from the perineum.
4. Irradiation via the vagina.
5. Any one of the above, plus partial or complete resection.

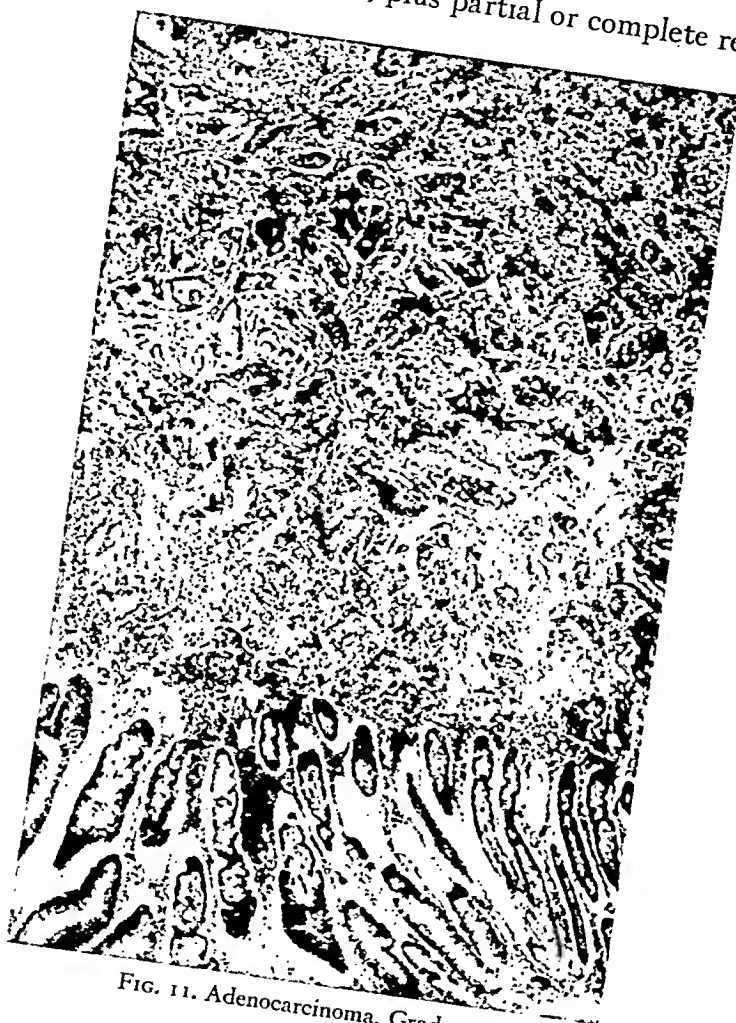


FIG. 11. Adenocarcinoma, Grade II.

6. High voltage Roentgen radiation.

A few years ago, two five-year cures were reported from the Mayo Clinic following the direct application of radium tubes to the surface of rectal cancers. The disadvantage of this method is that while a heavy dose of radium is delivered to the surface of the growth, a weak dosage is delivered to its base.

We have frequently employed radium emanation "seeds" 1 mc. in strength, which are imbedded in the base of the tumor via the rectal lumen; but it has been our experience that even employing only six to eight 1 mc. seeds, and with the caustic beta rays almost



FIG. 12. Area of excised tumor. Shows granulation tissue only.

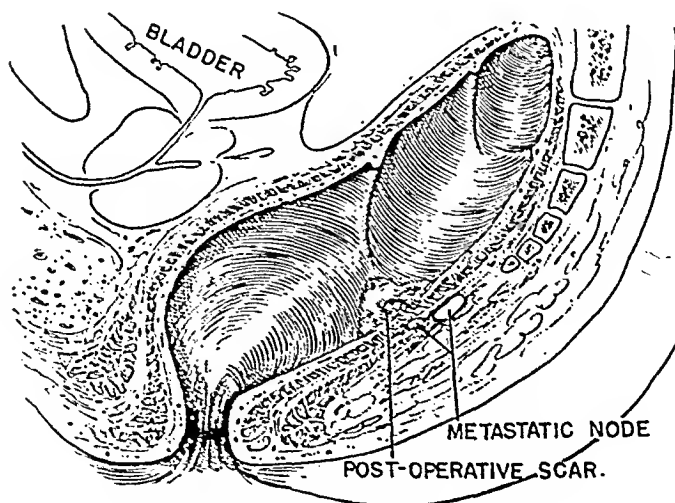


FIG. 13. Rectum just before resection.

entirely filtered out with 0.3 mm. gold, there is, nevertheless, usually a severe reaction. More recently we have been employing needles of radium element combined with electrocoagulation in divided doses. The preliminary results of treatment by this method are encouraging.

The technique of barrage by open operation is as follows:

1. An abdominal colostomy is formed.
2. The anus is closed and a wide exposure of the rectal ampulla is made through a median incision.
3. Employing radium element—long needles passed along the lines of lymphatic spread; shorter ones may be used to secure uniform and complete barrage of the growth. They are inserted along the hemorrhoidal arteries and the levators ani. They also are imbedded above, below, and into the growth. This may be combined with intracavitary surface irradiation.
4. As a fourth step, the rectum may be excised. The results are not very satisfactory. Convalescence is painful and slow; there is often a chronic urethritis and cystitis.

In females, of course, radium needles may be implanted in a growth of the anterior rectal wall via the vagina. This gives quite satisfactory palliation.

Several workers in this field urge a more frequent employment of colostomy and perineal resection, plus irradiation. They also urge partial resection in inoperable cases, plus irradiation. This method has merit if used with the inoperable cases; but we have not found that the colostomy and posterior excision, plus irradiation, has produced more cures than resection alone.

*Treatment with Roentgen Irradiation.* The technique of this type of treatment is improving with great rapidity. There has come swiftly an advance from the now commonly employed 200,000 volt apparatus to one with a voltage of 800,000, and finally to a machine operating with a voltage of 1,000,000. As regards the last, Dresser and Spencer have recently stated that the patient's skin "will tolerate twice as much x-ray delivered at 1,000,000 volts as it will at 200,000" and that "about 20 per cent more of the high voltage treatment will reach the center of the body." This allows the administration of more nearly adequate radiation to deep-seated neoplasms. The immediate results of 1,000,000 volt x-ray therapy, even though only palliative, are apparently superior to those obtained with lower voltage. It is of course too early to evaluate the

results of treatment of carcinoma of the rectum or sigmoid with this technique.

We must remember that radiation therapy has been applied to



FIG. 14. Metastatic carcinoma in tiny node behind area of excision of rectal cancer. (See Fig. 12.)

rectal cancer for only a little more than a decade, while surgery has been employed in this field for over a century, and secondly, that irradiation occasionally produces a clinical cure of many years' duration. The successful cases form such a small percentage of the total treated that we are all as yet duty bound to advise correct surgical excision in preference to radiation in those cases in which there is reasonable prospect of success.

We must recall, however, that a similar statement was true for cases of buccal cancer about eight or ten years ago. It is therefore not unreasonable to believe that, with the advancement of knowledge and with improved technique, our position may be altered.

#### SURGERY

*Preparation of Patient for Operation.* During the past few years we have found the following factors important in preoperative care of these patients: (1) The extension of the period of preparation to at

least seven days. (2) A high carbohydrate-low residue diet. (3) The reinforcement of carbohydrate intake by parenteral glucose 10 per cent. The fluid overcomes hypohydration. (4) If there is no suggestion



FIG. 15. Malignant adenoma.

of obstruction, magnesium sulfate in divided doses. However, there must be intestinal rest for forty-eight hours before operation, for it is highly important that the contents of the colon be solid at the time of resection. (5) Gentle, daily irrigation of the rectum and sigmoid with normal saline, which usually makes the patient more comfortable and thus adds to the sense of well-being.

We believe that in the management of these serious cases a trained team is of the utmost importance. One's surgical assistant should be a man especially interested in this sort of work—if possible, a man who has operated upon several of these cases himself—and alert to detect potential postoperative trouble. The nurse in charge should have a wide experience in their postoperative care. We have found that a specially trained nurse can often detect beginning



complications long before an individual not so experienced. It is vitally important, for instance, that the slightest sign of obstruction be reported immediately, and that the posterior staining be evaluated properly.

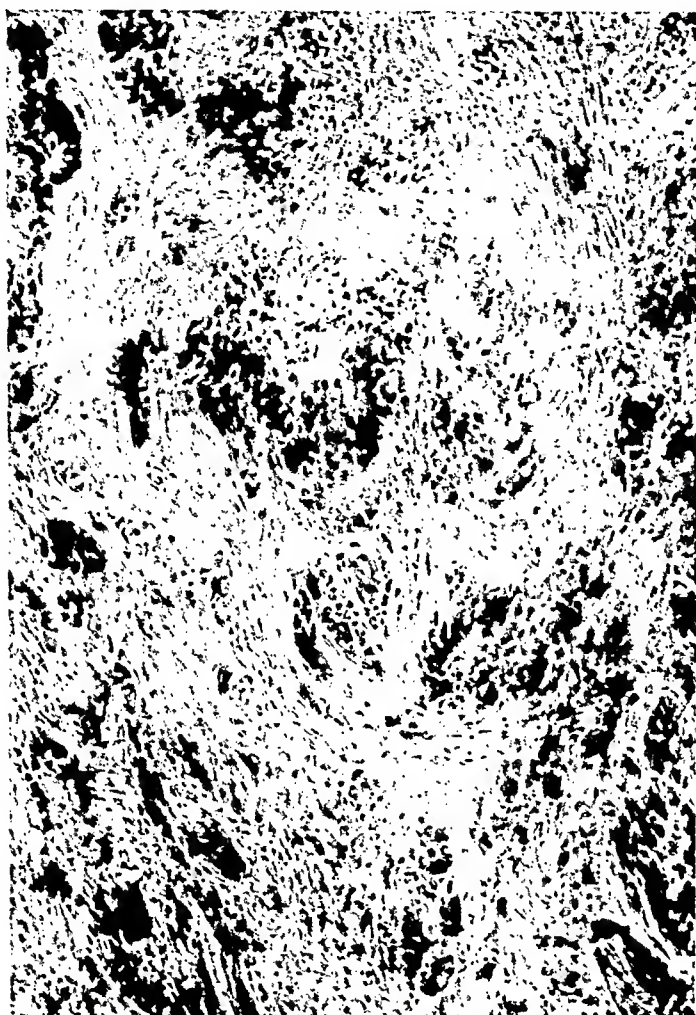


FIG. 16. Adenocarcinoma.

Each of our cases now has, besides the usual routine preoperative laboratory check-up and physical examination, a careful preoperative study and postoperative follow-up by the urologist and anesthesiologist. The anesthetic and urologic aspects of these cases will be discussed in detail below.

#### ANESTHESIA

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A patient undergoing a one-stage combined abdominoperineal operation for cancer of the rectum must combat three major factors

if he is going to survive such a severe procedure. First, usually he is beyond the optimum age group, in the average case being between 50 and 75 years old. Second, he is and has been for some time ill

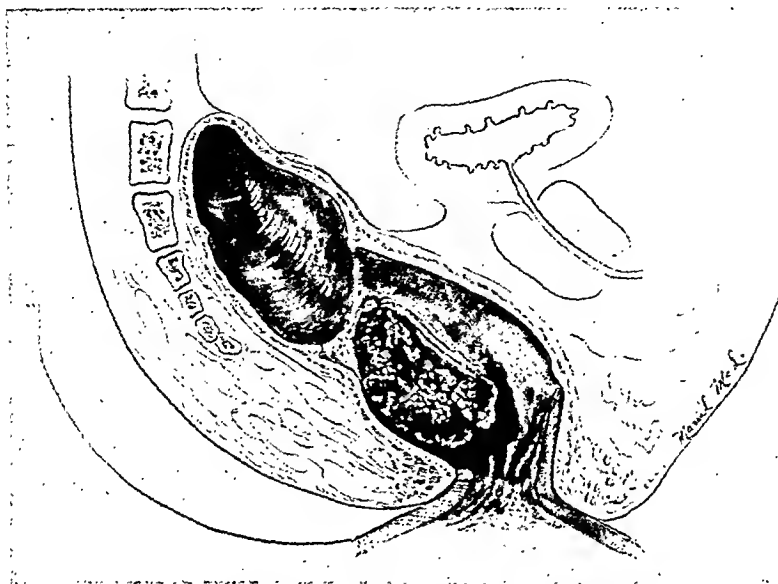


FIG. 17. Large soft tumor, clinically benign.

with a debilitating disease. Third, he is confronted with a long, shocking surgical procedure. The anesthetist primarily is concerned with the third of these factors.

To satisfy the anesthetic demands it is necessary to provide an anesthesia prolonged enough to last through the operative time, and at the same time one which adds as little as possible in the way of cardiac, respiratory, or vascular depression. Moreover, every advantage should be given the operator to work and complete this arduous piece of surgery. Consequently, we have come to believe very strongly that the anesthetic agent most commonly presenting these features is pontocaine.

Because this drug possesses all of the qualities and none of the disadvantages of procaine, as well as insuring twice the length of anesthesia, there seems no adequate reason for combining the two. So-called "slow takes" and "failure" of anesthesia are attributed to faulty technique rather than to any strange inherent property of the drug or idiosyncrasy of the patient. Furthermore, any diminution of the pontocaine dosage may shorten the duration of anesthesia. We have managed to obtain the desired and expected results with pontocaine as it is marketed, and therefore see no reason to alter the method of administration.

Pontocaine, as employed in these cases, was supplied in ampules containing 2 c.c. of the 1 per cent solution of the hydrochloride, representing 20 mg. Its advantages over the other spinal anesthetics

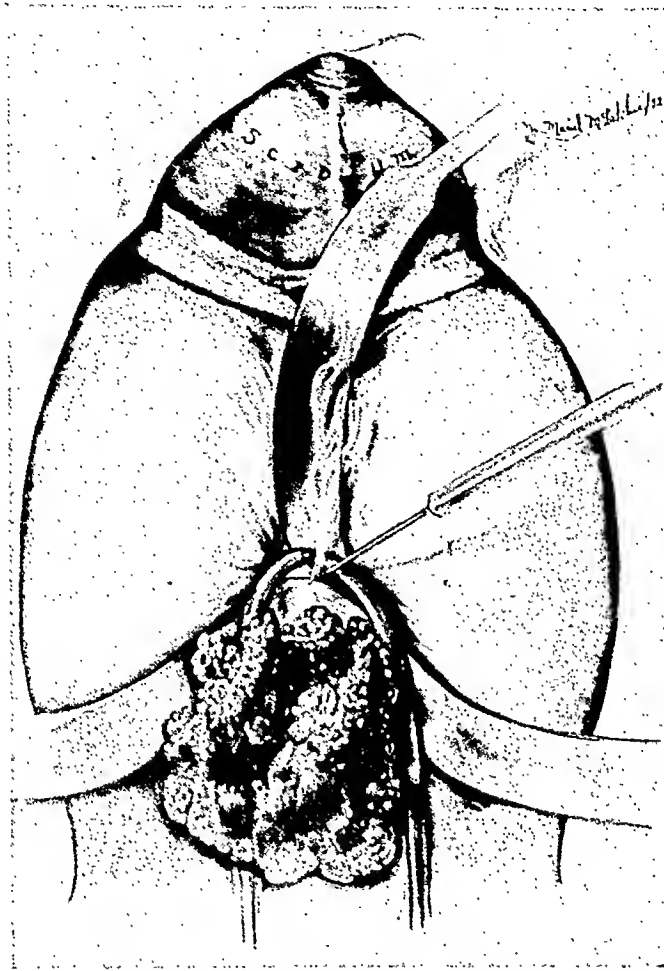


FIG. 18. Pedicle clamped with good margin of healthy tissue. Excision with electrocoagulation started.

in lower abdominal work are generally agreed to include: (1) anesthesia lasting between two and three hours; (2) ease of administration; (3) negligible respiratory depression; and (4) minimal lowering of the blood pressure. From these we feel that this drug causes the least amount of metabolic disturbance of the commonly employed spinal anesthetics.

While a few of these cases were operated upon while under nitrous-oxide-oxygen-ether anesthesia, in the great majority pontocaine was administered subdurally. The anesthetic of choice was always pontocaine. This was due to the many apparent benefits of spinal anesthesia for the lower abdomen over a general inhalation narcosis; these advantages are as follows:

1. Intestinal tranquillity, with no extrusion of intestines into the operative field.

2. Unparalleled muscular relaxation, permitting greater facility for operating, clearer exposure, and less trauma.

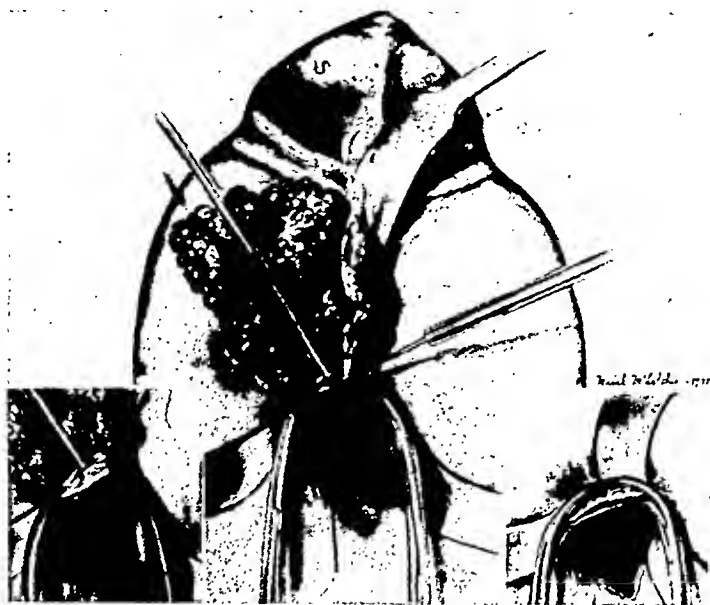


FIG. 19. Excision completed. Mattress sutures in pedicle for hemostasis.

3. Possibility of consulting patient in case of necessity.

4. Reduction of operating time by simplification of the technical aspects of surgery.

5. Shock reduced, due to posterior nerve root paralysis inhibiting impulses from reaching and acting upon the brain centers.

6. Fewer postoperative complications, since no mucus or vomitus is inhaled and thus there is less irritation to the mucous membrane of the respiratory passages.

7. Better approximation of wound edges, hence fewer incisional hernias, because of the relaxation; diminished nausea and vomiting and recovery restlessness.

8. Less toxemia compared to a long etherization, since the metabolic processes of the body are rested and reduced, thus conserving the patient's energy.

9. Especially useful in cardiac, pulmonary, and vascular states, as well as renal, liver, and diabetic cases.

10. Electrical apparatus (cautery) may be employed.

11. Postoperative recovery begins early.

12. Postoperative ileus is rare, due to less trauma of the intestines and increased peristalsis. Spinal anesthesia has been employed therapeutically in cases of paralytic ileus.



FIG. 20. Cancer of rectum. Pruritus was this patient's only complaint.

13. Less bleeding in the operative field because of the relative anemia and more constant blood pressure.

14. Hospitalization shortened because of fewer postoperative complications.

With regard to postoperative pulmonary complications under spinal anesthesia, no attempt is made to draw any dogmatic conclusions in this series. While we feel that there are fewer reasons for patients anesthetized with spinal anesthesia to develop such complications, there exists no unity of thought on this matter. Witness the following divergent findings of other reporters:

Brown and Debenham<sup>14</sup> state that "postoperative complications are 4.29 times higher under spinal anesthesia than under inhalation

anesthesia and the nearer the diaphragm the operation, the higher the incidence."

Stein and Tovell<sup>15</sup> report that "the incidence of postoperative complications is not increased."

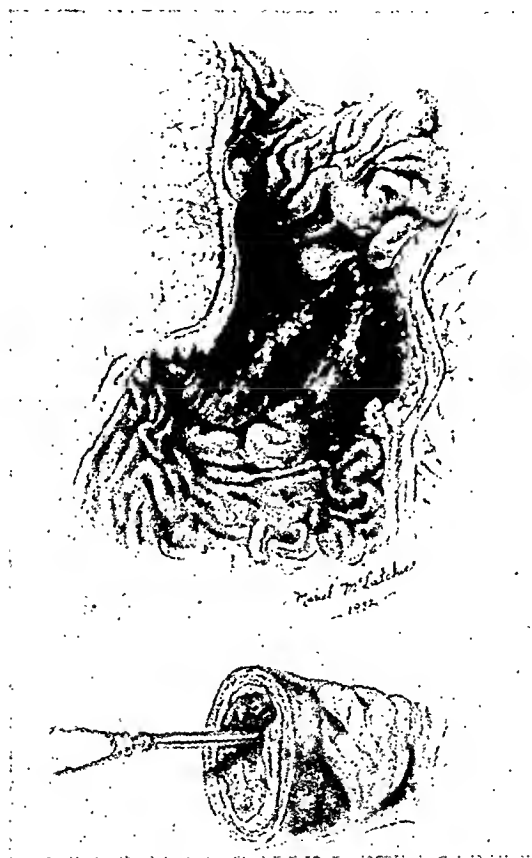


FIG. 21. Strictureing carcinoma of sigmoid. Oil relieved symptoms.

Flint<sup>16</sup> says that "the postoperative complications are no more frequent than after ether."

B. Rapoport<sup>17</sup> finds pulmonary complications after spinal anesthesia in 5.7 per cent of cases, and after general anesthesia in 7.4 per cent.

K. K. Nygaard<sup>18</sup> reports pulmonary complications after spinal anesthesia in 2.3 per cent of cases, and in 4.7 per cent of cases having general anesthesia.

Fowler<sup>19</sup> asserts that "spinal anesthesia is not followed by pulmonary complications."

In the preoperative preparation of the patient, the anesthetist plays an important rôle. He must make a study of the patient, and

should explain to him what is planned in regard to the anesthesia. There is thus established a bond of trust and confidence between the patient and the anesthetist. An examination of the patient's chart,



FIG. 22. Loop of sigmoid conceals carcinoma proximal to it.

with special reference to the history, physical findings, and laboratory work, should be made, followed by a personal check-up as to heart, lungs, and blood pressure. Inquiry should be made as to any idiosyncrasy the patient may have toward morphine, barbiturates, or other drugs to be used.

An attempt should be made to insure the patient a full and restful night's sleep by the administration of  $1\frac{1}{2}$  gr. (one capsule) of nembutal at bedtime, repeated at midnight if he is not asleep. In the morning nothing is allowed by mouth except 3 gr. (two capsules) of nembutal one and one-half hours preoperatively. This is followed fifty minutes later by morphine and scopolamine together, in dosage commensurate with the patient's age, weight, and physical findings. Usually morphine gr.  $\frac{1}{6}$  and scopolamine gr.  $\frac{1}{150}$  act well enough to calm the average patient. By virtue of this premedication, many of the people operated upon fall into a profound sleep after the operation has begun; at least, if not asleep, their senses will have been dulled and their apprehension destroyed.

In giving the pontocaine, the following steps are observed: From 2 to 3 c.c. of a 1 per cent novocaine solution, to which is added 50 mg.



of ephedrine, are injected into the skin and underlying structures at the site of the spinal puncture. As this operation for cancer of the rectum is to be confined to the lower abdomen, the usual injection



FIG. 23. Carcinoma of sigmoid revealed by pushing loop to one side.

site is the third lumbar space. The injected ephedrine tends, by its direct vasoconstricting action on the terminal blood vessels, to prevent a fall in blood pressure. Therefore it is best, if possible, to wait ten minutes for its full effect. The operating table at this time is flat, or in not more than 10 degrees Trendelenburg position.

After the introduction of the spinal needle (No. 22 gold needle with a Sise introducer), 2 c.c. of spinal fluid are withdrawn and mixed with an equal volume of the 1 per cent pontocaine solution in a 10 c.c. syringe. From this mixture of 4 c.c., any desired dose may be reinjected, each cubic centimeter containing 5 mg. of the drug. In these cases of resection of the rectum, 20 mg. were routinely employed, with the injection rate  $\frac{1}{2}$  c.c. per second. The patient is now turned on his back and the necessary preoperative procedures carried out, such as adjusting the blood pressure cuff and stethoscope, placing the shoulder pieces in position, and generally making the

patient comfortable. Preparing the operative field and draping add a few minutes more. When all these preparations have been completed, anesthesia is present to some height above the umbilicus, and the operation may begin.

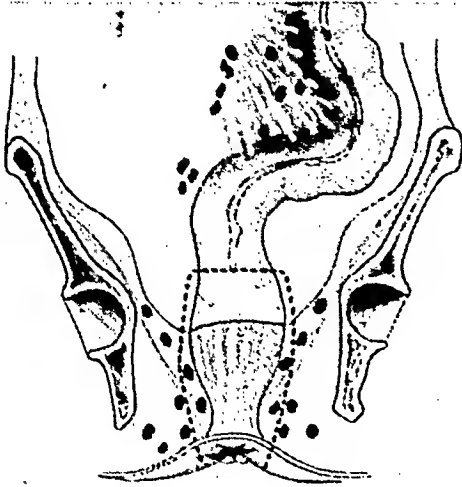


FIG. 24. Black dots represent metastases in ischio-rectal fossa, levatores ani muscles and sigmoid mesentery. (From Miles' "Cancer of the Rectum.")

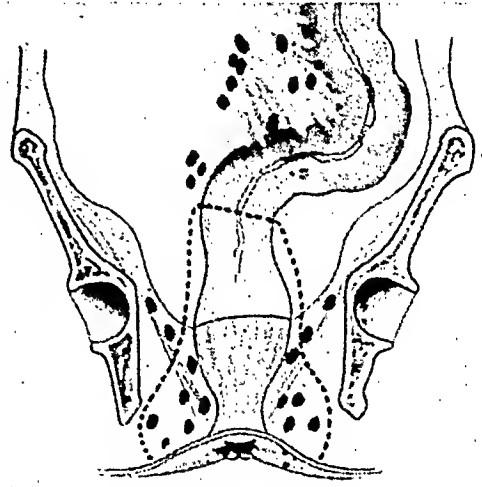


FIG. 25. Broken line represents tissue excised. (From Miles' "Cancer of the Rectum.")

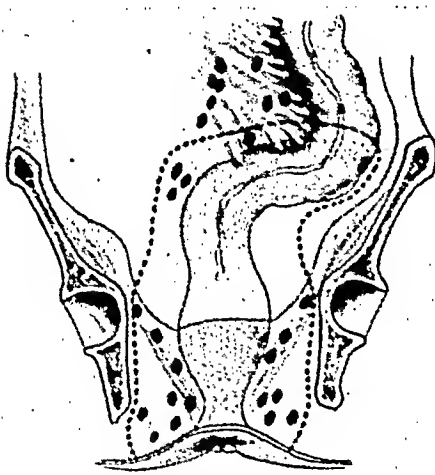


FIG. 26. Cancer left in sigmoid mesentery. (From Miles' "Cancer of the Rectum.")

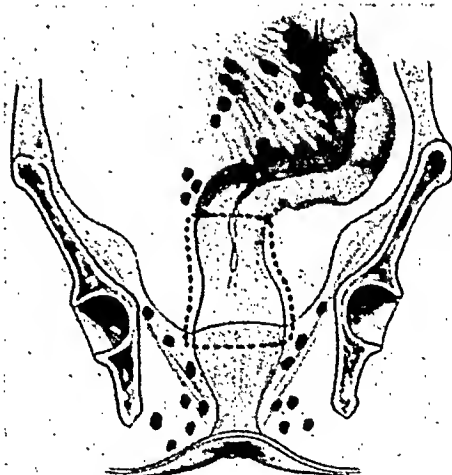


FIG. 27. Sleeve resection. A bad operation for cancer of rectum. (From Miles' "Cancer of the Rectum.")

The technique described above may have to be slightly modified in certain individuals with difference in the specific gravity of the spinal fluid, or with variations in the configuration of the vertebral column.

Approximately when the surgeon is ready to open the peritoneum, or about fifteen minutes after the injection of the pontocaine, the table may be placed in as much Trendelenburg position as is

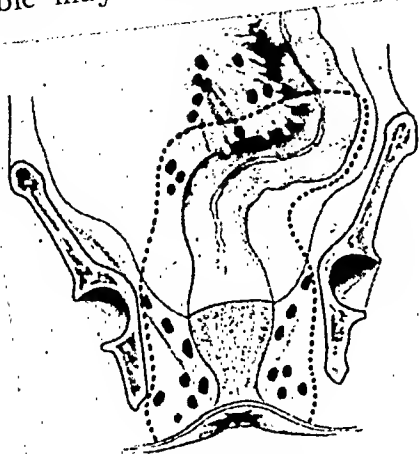


FIG. 28.

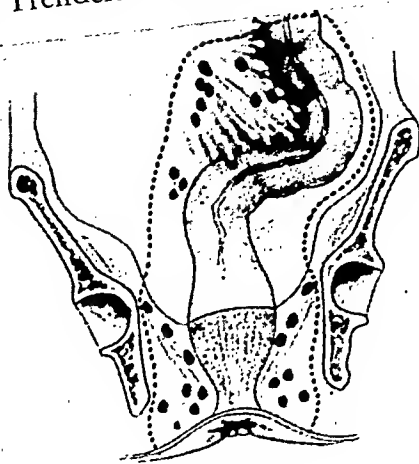


FIG. 29.

FIGS. 28 and 29. Operation not radical enough, though an improvement over the preceding procedures. (From Miles' "Cancer of the Rectum.")

required. By this time the drug has become fixed in the spinal canal and no further rise cephalad may be expected.

It is our rule that fifteen minutes prior to the time when the first stage is to be completed and the patient turned, 50 mg. of ephedrine are injected subcutaneously in order to bolster the blood pressure for this change of position. We have found that as the patient is turned onto his side for the second stage, shock—as evidenced by a falling blood pressure and a rising pulse rate—is imminent. This is combated by the above-mentioned ephedrine, intravenous fluids, Trendelenburg position, and transfusion.

Following the completion of the operation, the patient is always placed in his bed, which has been brought directly to the operating room. This does away with the necessity of forcing the patient to undergo an extra transference from litter to bed. If required, bed and patient may be left in the operating room while any remedial measure is carried out.

Upon return to the patient's room, the bed is immediately placed in Trendelenburg position, and left in that position for at least four hours. This procedure, coupled with the use of the fine gold needle, is given credit for the total absence of postoperative lumbar puncture headaches in this series.

Other postoperative care includes the liberal use of morphine after the spinal anesthesia has worn off; instruction for the turning

of the patient frequently, at least once an hour; encouraging the patient to breathe deeply for several periods each hour while awake, either with or without the aid of carbon dioxide; and forced move-

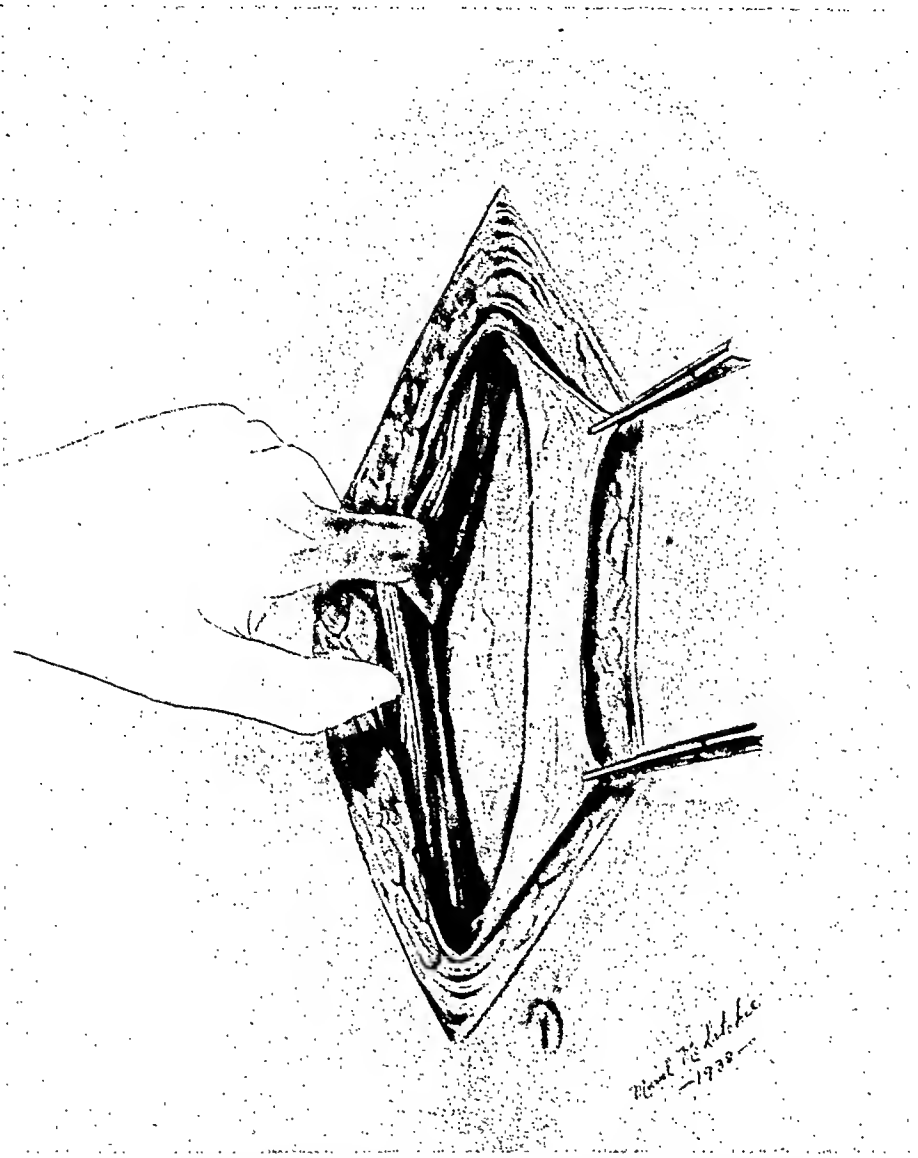


FIG. 30. Left paramedian incision. Left rectus muscle retracted.

ments of the arms and legs. These last measures will counteract the depressant effect of the morphine on the respiration. Since the condition of hypoventilation exists in most cases after an abdominal operation, with many minute deaerated areas in the lungs, this treatment will militate against the production of pulmonary complications by more promptly returning the vital capacity to normal. Moreover, the possibility of massive collapse due to mucus occluding a bronchus is diminished. In this series only one patient died of bronchopneumonia postoperatively.

There were no sudden anesthetic catastrophes on the table in this group of cases; nor did any of them have a serious respiratory or cardiac depression. However, in the event of a cardiac depression

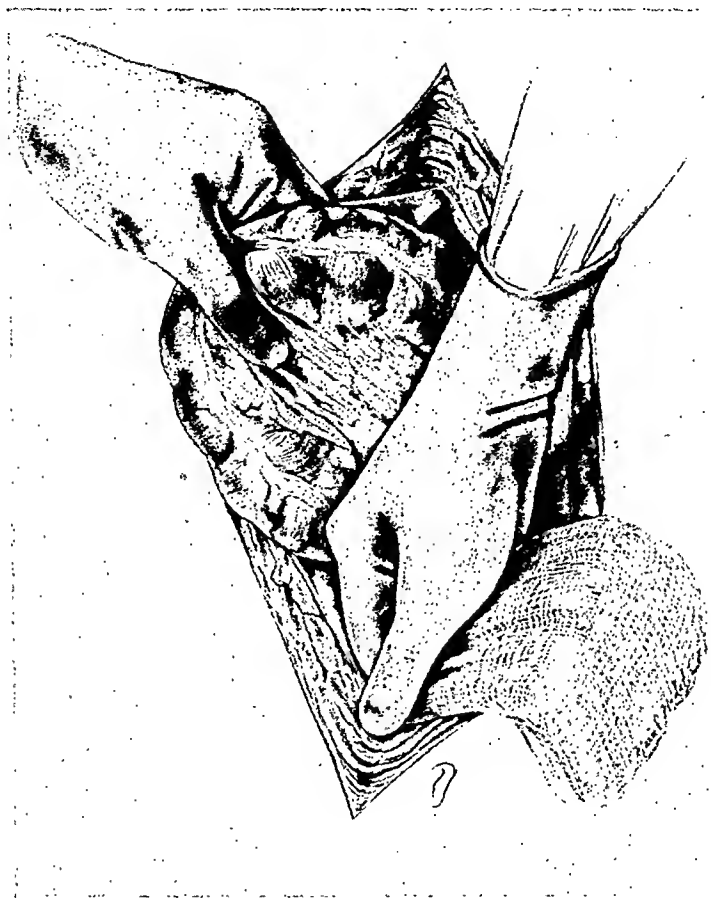


FIG. 31. Patient is in Trendelenburg position.

with a serious drop in blood pressure, it is our belief that this condition is most advantageously treated with ephedrine, which seems to give more prompt effect if administered by intravenous injection. Respiratory depressions should be treated with oxygen inhalations, artificial respiration, and the use of metrazol or coramine intravenously.

There were no neurologic sequelae reported as a result of these spinal anesthetics. Nausea was encountered occasionally, and treated with oxygen inhalations. Restlessness on the operating table was counteracted by sedatives during the operation.

In conclusion, it may be stated that the anesthetic problem in this combined abdominoperineal resection of the rectum in one stage

has been to find an intraspinal agent causing anesthesia and motor paralysis, while at the same time not producing a paralytic effect on the vegetative medullary centers. We believe that pontocaine, pre-

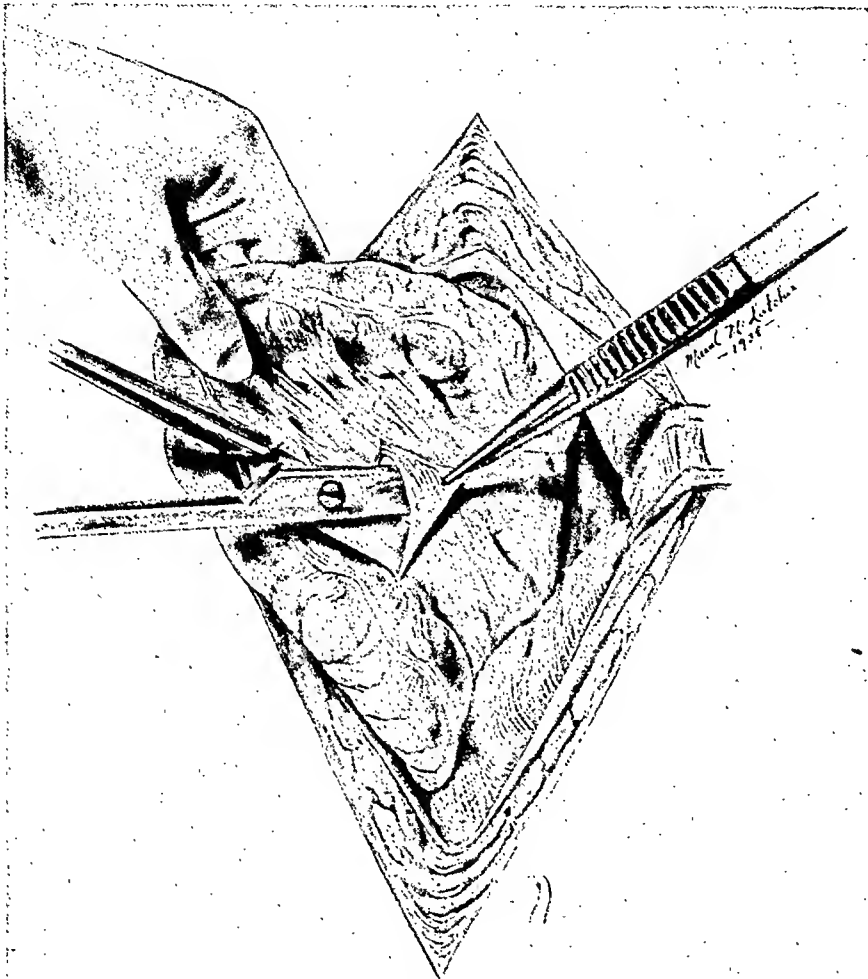


FIG. 32. Peritoneum freed off mesosigmoid with large obstetrical scissors.

ceded by the neutralizing effect of ephedrine, answers these demands satisfactorily.

#### UROLOGIC MANAGEMENT

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Assistant Urologist, Carney Hospital

Very little has been written on the urologic complications of carcinoma of the rectum and the frequency with which these occur has not been generally recognized. In a recent review of 440 cases at the Pondville Hospital, Kickham and Bruce found that in the early, or operable group, 30.4 per cent of the males and 36.7 per cent of the

females complained of urinary symptoms. In the late or inoperable cases these figures rose to 60.7 per cent of the males and 46.6 per cent of the females. When the disease was adherent to the



FIG. 33. Ligation of superior hemorrhoidal artery.

prostate, the incidence of urinary complaints was almost twice as high as when the lesion was situated posteriorly.

At the request of Dr. Shedden we have assisted in the urologic study and management of many of his cases, and present herewith the routine which we have employed.

During the week in which the patient is in the hospital prior to operation opportunity is afforded for the preoperative study. We begin by taking a careful history, paying special attention to previous kidney or bladder disease, as well as any illness which might indirectly affect the status of these organs. Evidence of bladder disturbance in the present illness is sought. (Table ix.) Following an abdominal examination with special reference to the kidney and bladder regions, the external genitals are examined, and finally the



rectum, with particular attention being paid to the condition of the prostate and the nature of the growth and its possible relationship to the bladder, prostate and urethra.

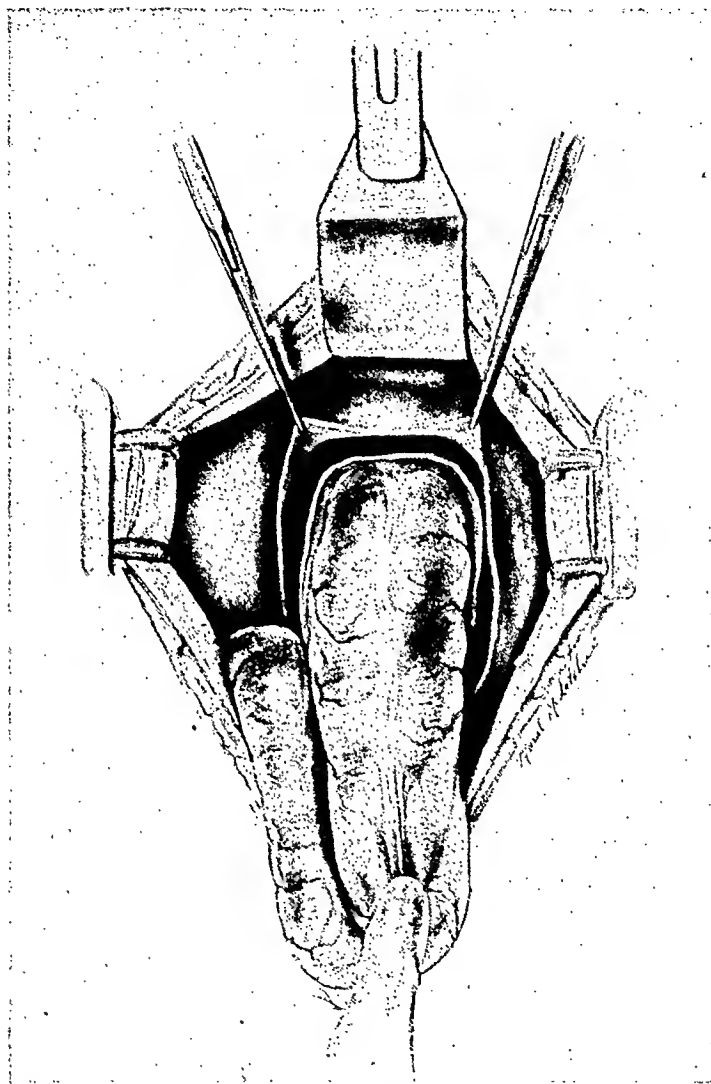


FIG. 34. Peritoneal flap turned off bladder and mesosigmoid.

Every case should have an estimation of the blood nitrogen, and a routine phthalein test should be done. These tests, in con-

TABLE IX  
UROLOGIC SYMPTOMS ON ADMISSION

	Cases
Dysuria.....	5
Frequency.....	12
Nocturia.....	15
Difficulty starting.....	6
Dribbling.....	1
Total number of cases with urinary symptoms.....	39

junction with the rest of the study, throw light not only on the condition of the urinary tract, but also on the patient as an operative risk. When major surgery is to be performed it is just as important

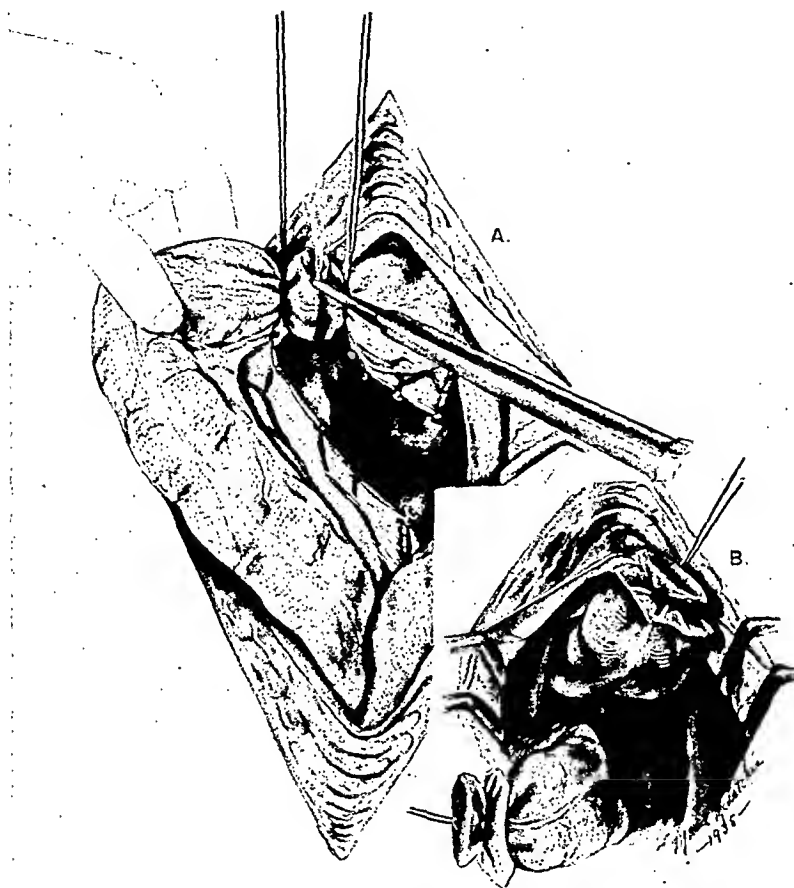


FIG. 35. A, sigmoid sectioned with cautery after crushing and ligating with heavy silk. B, rubber caps tied securely over stumps of bowel.

to investigate the kidneys as the heart. To the same end a daily record of intake and output is kept, and specimens of urine are examined for evidence of infection or nephritis. If renal function is found to be impaired it is important to determine whether this impairment is due to intrinsic renal disease or to obstruction within the urinary tract by the tumor or by causes independent of the tumor. Cystoscopic examination may be necessary. Inspection of the bladder may reveal distortion due to extravesical pressure, or actual invasion by tumor. The latter is often accompanied by ureteral occlusion which may seriously militate against successful

surgery. Visualization of the ureters by retrograde or intravenous pyelography is done if indicated, and should be very seriously considered in the moderately advanced cases of borderline oper-

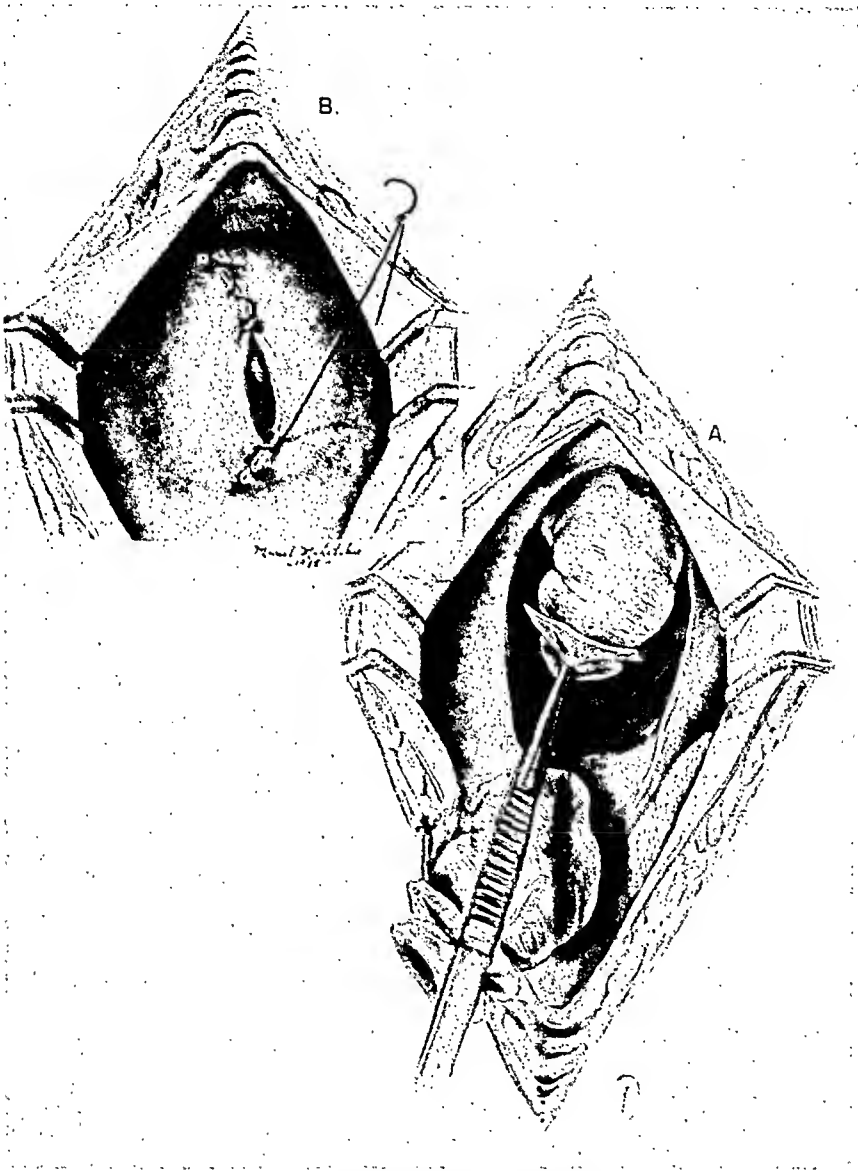


FIG. 36. A, distal stump turned down into pelvis. B, pelvic floor reconstructed from peritoneal flaps.

ability. Kickham and Bruce found that in eighty-eight post-mortem examinations on advanced cases, forty-one or 47.7 per cent showed obstructive changes in the upper urinary tract secondary to occlusion of the ureters by malignancy.

If no indication for cystoscopy has been found it is our custom to pass a soft rubber catheter to determine the residual urine and obtain a sterile specimen for culture. If infection is found to be present

the organism is isolated and appropriate treatment is given to sterilize the urine preoperatively. At the same time in many of the cases cystometrograms have been made in an effort to throw more

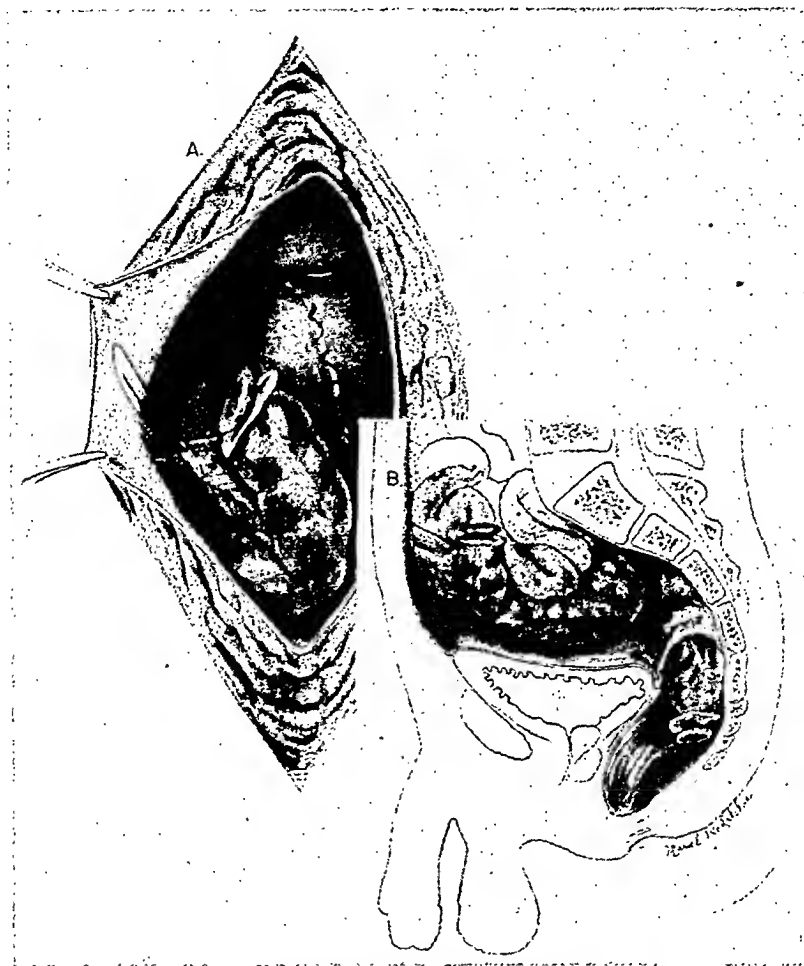


FIG. 37. A, closure of left lateral gutter, suturing stump of mesosigmoid to left lateral wall. B, lateral view of same.

light on the reasons for and nature of vesical dysfunction when it occurs as a postoperative complication. We are not prepared as yet to draw conclusions from these cystometric data.

Before operation a No. 16 double-eye catheter is introduced under the most rigid asepsis and is adjusted at a level of maximum efficiency. This is left in place during the operation and thereafter as long as necessary. During this time it is disturbed as little as possible and is not changed or even irrigated unless there is reason to believe it is not draining freely. In this way the danger of introduction of

infection into the urinary tract is reduced to a minimum. While the catheter is in position a daily watch is kept for urethritis, which if marked demands removal of the catheter to prevent a periurethral

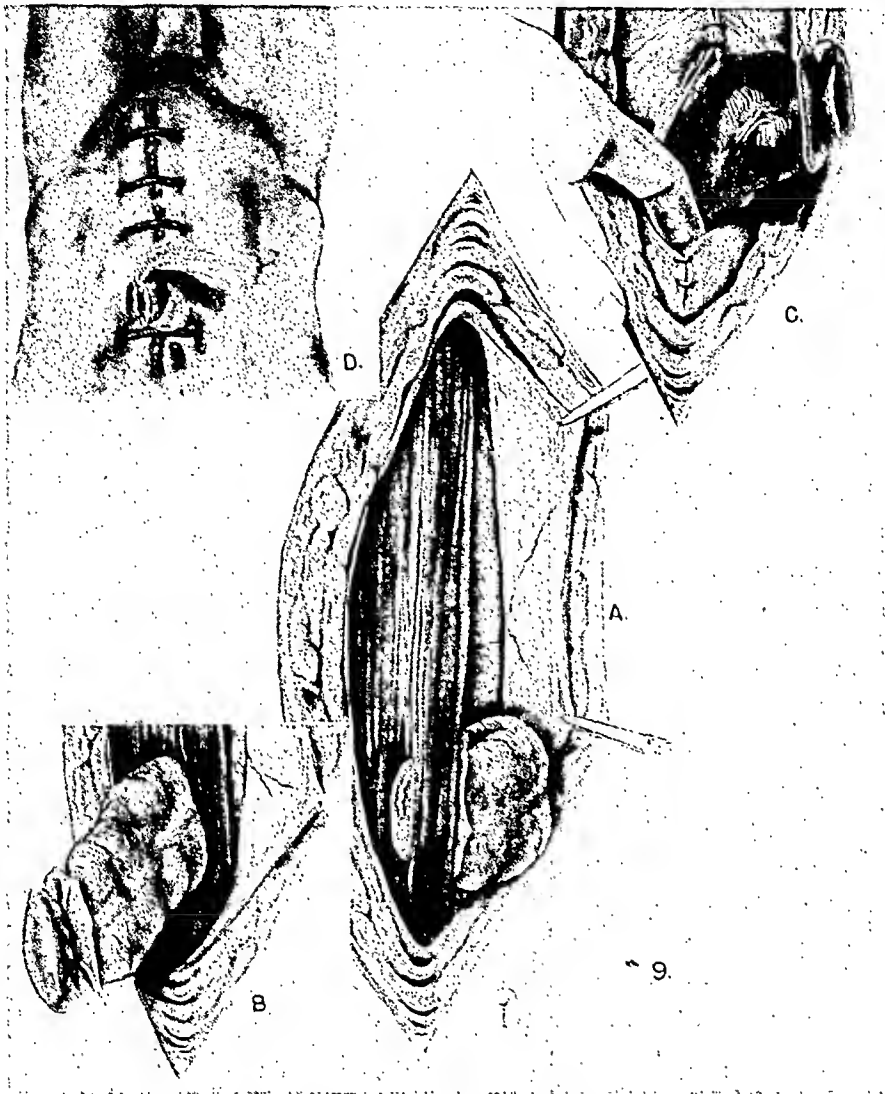


FIG. 38. A and B, proximal stump (colostomy) protected by rubber cap being drawn through split in proximal third of left rectus muscle. C, fascia sutured loosely around colostomy. D, skin clips and "through-and-through" sutures in place.

abscess. It is rather surprising that epididymitis has not been encountered except in a few cases where it occurred in the mildest form. Consequently vasectomy as part of the routine preparation of male cases has not been employed. The catheter is usually left in place for eight to ten days until the posterior pack has been taken out or until the patient is able to be out of bed. We have removed it as early as the fifth day. The patient need not be catheterized

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 again unless clinical signs point to considerable bladder retention.  
 The same preoperative program of urinary antisepsis may be continued after operation.

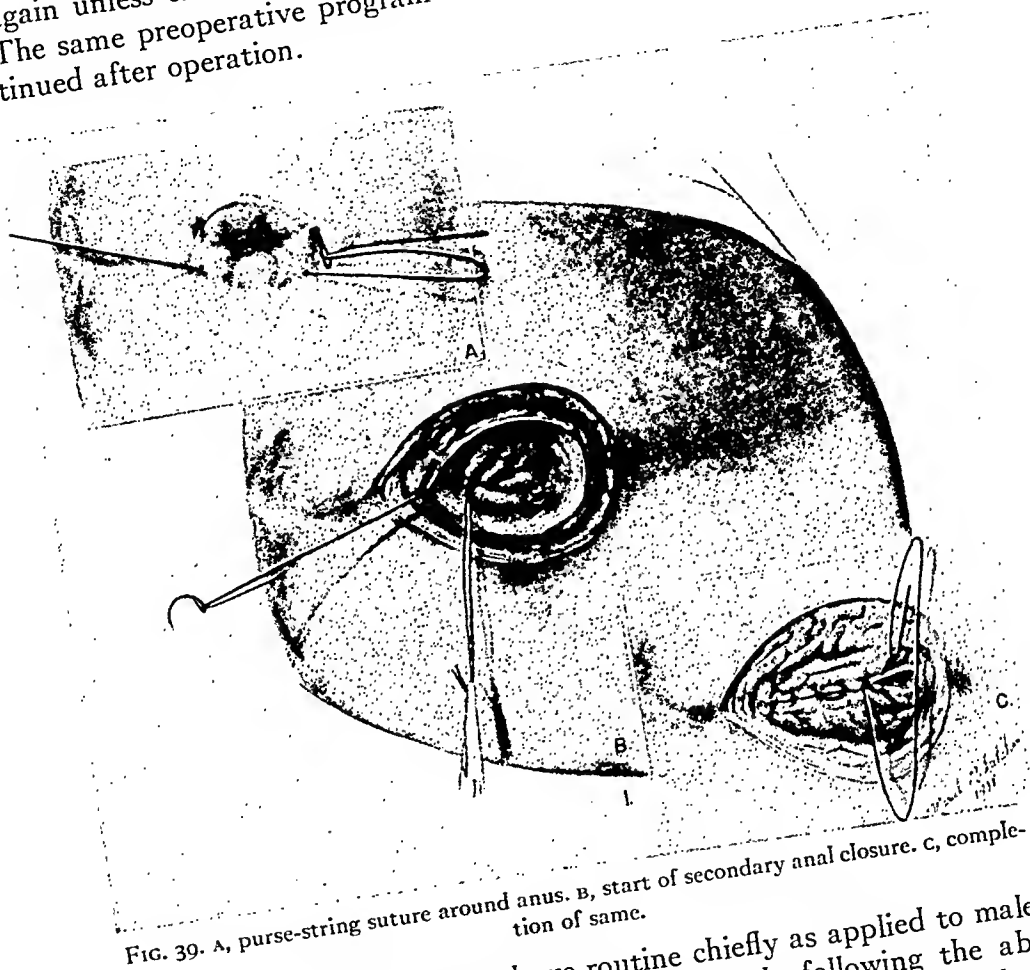


FIG. 39. A, purse-string suture around anus. B, start of secondary anal closure. C, completion of same.

We have discussed the above routine chiefly as applied to male patients. Urinary complications in the female following the abdominoperineal resection of the rectum are much less frequent, but the same fundamental principles apply. In Dr. Shedden's cases the urologic difficulties have been reduced considerably by this régime, and although our management of the bladder is very simple, the results have been more satisfactory than with complicated apparatus such as tidal drainage.

As yet we have no definite explanation for the bladder dysfunction which has commonly followed the abdominoperineal operation in the past. Apart from infection one might predicate the following three theories:

1. Neurogenic dysfunction because of injury to the nerve supply.
2. Removal of the normal supports of the bladder and urethra.

3. Trauma to the bladder and its sphincter mechanism incident to the operative procedure.

It is of interest in this connection that dysfunction does not occur after the first stage of a two-stage operation. Doubtless the most important factor in minimizing these difficulties is meticulous care on the part of the surgeon in avoiding injury to the ureters, bladder, prostate, and urethra, together with their nerve supply.

### THE OPERATIVE THERAPY OF CANCER OF RECTUM AND SIGMOID

The operative therapy may be divided into that which is palliative and that in which an attempt is made at a cure.

#### PALLIATION

It is our belief that all patients with incurable growths should have a colostomy. We do not urge colostomy on these patients, but offer it as a probable partial relief of symptoms—recognizing the fact that though the procedure is simple, it carries a definite mortality. In this group, twenty-five in number, there were four hospital deaths. The criteria of inoperability were: (1) extensive invasion of the tumor in the pelvis with marked fixation; (2) old age; (3) poor general condition; or (4) any combination of the above.

Colostomy does more than relieve obstruction. If the loop is cut across, and the distal segment irrigated with normal saline, a large number of patients are partially relieved of the symptoms of rectal irritability. A judicious use of radium "seeds" or needles may further enhance the patient's comfort. Many patients have increased appetite and have gained weight, occasionally as much as 40 pounds.

#### RADICAL RESECTION

The criteria for selection for radical operation are: the extent and type of lesion; the presence or absence of obstruction; and lastly, and most important, the evaluation of the patient as an operative

TABLE X  
APPEARANCE ON ADMISSION\*

	Cases
Well-nourished.....	51
Fairly well-nourished.....	17
Poorly nourished.....	9
Obese.....	9
No mention.....	25
Total.....	111

\* 75 per cent were well nourished.



risk. Obesity adds definitely to this risk. Chart xii. One individual in this series weighed 203, another weighed 206, while a third weighed 213.

We must attempt resection whenever possible, even if metastases are present in the liver, for the untreated case of carcinoma of the rectum lives an average of two years, sometimes longer, and those years are full of pain and misery.

In every instance where the bowel is resected for carcinoma of the rectum, the employment of a colostomy must be part of the operative technique. There is no question that the development of radical surgical procedure against rectal cancer has been retarded by a prejudice on the part of physicians as well as the public toward accepting an abdominal anus. Fortunately, however, the majority of physicians now accept the necessity of a colostomy. That a colostomy can be tolerated without physical limitations or social stigma we have indicated in a previous paper.<sup>8</sup> Attempts at restoration of bowel continuity in these cases will result in a high percentage of recurrence at about the same level as the original tumor. Partial stricture is the rule after this procedure, and there is often loss of sphincter control. We deplore the appearance in recent literature of pleas for this almost discarded operation. If it is again accepted, we will see a decreasing percentage of five-year cures and increasing postoperative discomfort, sepsis, and bowel malfunction.

#### MORTALITY AND OPERABILITY

Though operative mortality should be reduced and operability increased with maturing experience, as has been shown in this series, yet surgical mortality must be given second place when dealing with the case of borderline operability.

The resection operability for this total series of 111 cases is 73.8 per cent; the resection mortality 13.4 per cent. If we divide the group of resections into two halves, we find that the earlier group of forty-one cases carried a mortality of 21.9 per cent, with an operability figure of 73.8 per cent; while in the second group of forty cases there was a mortality of only 4.9 per cent, with an operability of 76 per cent. (Tables xi and xii.) There have been no deaths in the last twenty-two cases. This marked reduction in mortality we ascribe to the development of an adequate hospital "team," plus more careful preparation and improvement in operative technique. (See Table xiii.)

In considering operability, we must decide whether we will operate merely on those whom we believe we can cure, or add to the

TABLE XI  
MORTALITY AND OPERABILITY

111 cases (all operations)	}	Mortality 12.8 per cent
14 deaths		
82 resections	}	Mortality 13.4 per cent
11 deaths		
Last 41 resections	}	Mortality 4.9 per cent
2 deaths		
Last 41 resections	}	70.7 per cent one-stage operations
29 one-stage operations		
Last 22 resections	}	Mortality 0
No deaths		

TABLE XII

MORTALITY RATE FOR EIGHTY-TWO RADICAL RESECTIONS OF THE RECTUM, 13.9 PER CENT

MORTALITY RATE  
FOR 82 RADICAL RESECTIONS OF THE RECTUM: 13.4 %

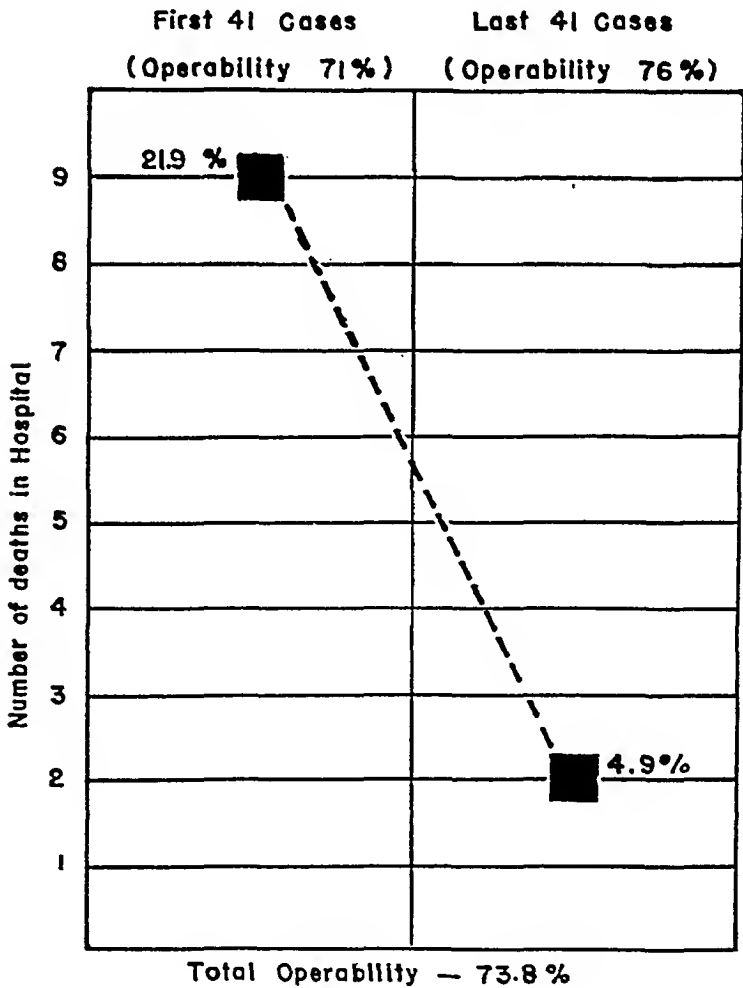


TABLE XIII  
RADICAL RESECTIONS

Source of Information	Percentage One-stage Resection	Operator	Percentage Mortality All Resections	No. Cases	Operability
Personal communication, 8/38.....	47	A. W. Allen	13.0	108 (most recent)	90 (approx.)
Personal communication, 5/38.....	28	Cattell and Lahey	13.5	245	72.0
Personal communication, 6/38.....		Cattell and Lahey	13.0	100 (most recent)	81.3
	72	E. P. Hayden	13.4	82	76.6
Personal communication, 11/38.....	78	E. P. Hayden	9.8	41 (most recent)	77
		T. Jones	9.0	174	88.5
Personal communication, 7/38.....	94	T. Jones	9.5	54 (most recent)	
Personal communication, 5/38.....		L. S. McKittrick	9.0	100 (most recent)	
Personal communication, 8/38.....	71				34.0
	37	13 surgeons	32.0	100	71.4
Morton in <i>Surg., Gynec. &amp; Obst.</i> , 66: 769, 1938.....	75	F. W. Rankin	11.8	578	76.0
J. A. M. A., 109: 1719, 1937.....	76	F. W. Rankin	6.5	107 (most recent)	
Personal communication, 5/38.....		W. M. Shedden	13.4	82	73.8
	59	W. M. Shedden	4.9	41 (most recent)	76.0
	70.7				

list advanced borderline cases so that they can be made more comfortable mentally and physically for one or several years. We have included, therefore, in our group of resections, many whose prognosis was bad. This is shown by the fact that in 29 per cent the growth had already invaded blood vessels.

Several cases had other coëxistent pathology. Case 30, for instance, had 6 per cent sugar in the urine, fairly large bilateral ovarian tumors and a growth involving the vagina extensively. However, a one-stage resection was accomplished. She is living without disease two and one-half years since operation. Two patients had cholecystitis. In one instance (Case 60) the disease remained chronic, but in the other (Case 48), there was an acute attack during convalescence from the resection. It fortunately quieted down, however.

Of the group of eighty-two patients who had bowel resections, there are forty-six who have lived without disease for more than six months. (Table XIV.)

TABLE XIV  
DURATION WITHOUT DISEASE

	No. of Cases
12 years.....	1
6 years.....	4
5 years.....	7
4 years.....	5
3 years.....	9
2 years.....	7
1 year.....	12
6 months.....	2
<hr/>	
Less than 6 months since operation .....	5
<hr/>	
	51

It is important to select the type of resection best adapted to the individual patient. Usually this can be decided after careful examination and appraisal of all the factors in the case, but not uncommonly the final decision can be made only after the abdomen has been opened and explored.

From time to time various two-stage abdominoperineal procedures have been developed: the graded resection of Daniel Jones; that of Coffey; more recently, those of Rankin and of Lahey. All these are excellent, but invariably, with added experience, their inventors swing toward the one-stage procedure. It is the consensus of most surgeons that the one-stage procedure should be employed whenever possible.

It is our opinion that until adequate experience is gained, a two-stage operation should be performed. However, under proper auspices, approximately 75 per cent of the cases can be resected by the one-stage technique, with no higher mortality than with any two-stage method. This is illustrated by Table XIII which shows the percentage of total resections performed by the one-stage technique, with the mortality and operability figures.

We say "under proper auspices" advisedly, for we feel that the mortality with the one-stage operation will always be too high unless the patient is meticulously and slowly prepared for operation, as has been described above, and unless the surgeon always works with a trained team, as Morton's report in Table XIII clearly demonstrates.

Dr. Daniel Jones has done more, perhaps, than any other man in America to advance surgery of the rectum. Jones states:<sup>11</sup> "I have gradually increased the number of one-stage operations and decreased the number of two-stage operations and believe that this should be done as men find their ability to do the one-stage operation." In the period of 1932 through 1936, the last years of Dr. Jones's operating career, he did eighty-nine operations, and fifty-six of these were *one-stage* combined abdominoperineal operations, or sixty-three per cent of the total radical operations.<sup>10</sup>

Dr. Fred W. Rankin says:<sup>5,6,7</sup> "I find myself doing about three out of four cases by some type of resection and about three-fourths of the whole group by a one-stage procedure. I formerly advocated the two-stage procedure . . . but when I found that I was able to do a one-stage operation with a low mortality, I was perfectly willing to admit that my two-stage one was not very useful and that the bad cases should be operated upon by the colostomy and posterior resection type of procedure."

Dr. Thomas E. Jones<sup>12</sup> states: "I am certainly intending to do more one-stage resections than ever before."

Dr. Leland F. McKittrick says:<sup>13</sup> "I have always felt that the one-stage operation was the operation of choice and that as any individual man's experience increased up to a certain point, the number of operations he would do in one stage would also increase. There still remains, however, a definite group which I feel should be done in two stages, where the risk of the one-stage procedure is too great. This holds particularly with many older, poorer risk patients with a low growth where colostomy and posterior excision may be the procedure of choice."

We utilize six different types of resections: the one-stage combined abdominoperineal resection (Miles)—59 per cent (70.7 per cent of the last forty-one cases); the abdominoperineal resection in two stages (Lahey); the abdominoperineal resection in two stages (Jones); the posterior or perineal resection following a loop colostomy in two stages; and for the sigmoidal growths, the anterior resection or the Mikulicz.

In this series of 111 cases, radical resections were attempted in eighty-three instances and completed in eighty-two. In one instance, the operation had to be abandoned after the first stage.

In the treatment of this disease, the one-stage abdominoperineal operation, as developed by Mr. Ernest Miles of London, is without question the ideal therapy. Obviously it cannot be employed in poor-risk cases—about 25 per cent of the operable cases—as it is a formidable procedure. But to date, in our opinion, a better therapy for this condition has not been found. Figures 24 to 29 inclusive show the evolution of this operation from the Kraske-procedure.

#### THE MILES OPERATION

This operation we do through a left paramedian incision and retract the rectus laterally. (Fig. 30.\*) We have abandoned the original suggestion of Miles that the abdomen be entered through a right rectus incision and that the colostomy be pulled out through a stab wound at the left. The latter procedure makes a closure of the left lateral fossa more difficult and also interferes with the delivery of the colostomy of the abdominal surface in cases with short sigmoid mesentery.

We examine the liver for metastasis as a routine procedure, though of course absence of palpable nodules on the surface does not rule out metastasis elsewhere in the liver. However, we do not hesitate to resect the rectum even if nodules are palpable if the patient is otherwise operable.

The mesentery of the descending colon, sigmoid and rectosigmoid is palpated for nodes, but obviously their presence does not rule out resection. Not uncommonly these glands are enlarged and hard simply as a result of secondary infection of the ulcerated growth. Within the past year we have twice resected sigmoids within the mesentery of which were large, hard glands. None of these glands

\* Figures 30 to 43 are a series of drawings by Muriel McLatchie based on a motion picture of a modified Miles operation performed by the author.

contained metastases. The presence of a large growth does not preclude resection, nor does fixation to dome of bladder or vaginal septum, but extensive fixation (particularly to the lateral walls of

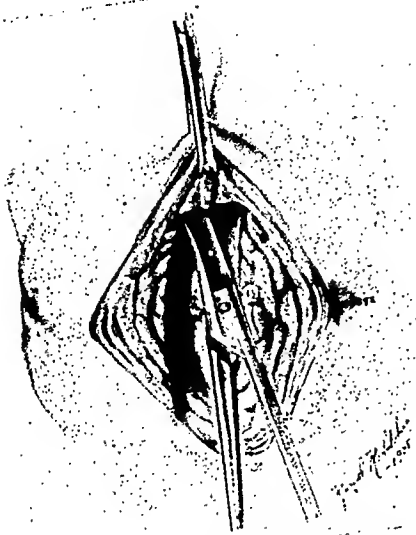


FIG. 40. Start of removal of perineal fat over lateral attachment of levatores ani.

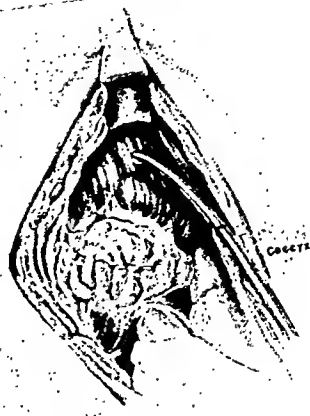


FIG. 41. Section of levatores ani.

the pelvis) may. Radical operation on this latter group may invite disaster. Four years ago we attempted resection on such an advanced growth. The attempt was made because the patient was in almost constant pain, but the operation had to be finally abandoned when it was discovered that the growth was solidly stuck to the left side of the pelvis and had encroached on several large vessels. Improved neurosurgical technique now renders such heroic efforts at palliation unnecessary. This type of case now receives subtheal alcohol injection or cordotomy by a neurosurgeon.

We have frequently resected the presacral nerve, but have not been able to convince ourselves that it was of much avail in the relief of pain in carcinoma of the rectum or sigmoid.

After the abdominal exploration has been completed, and the small intestine packed back (Fig. 31), the distal large bowel is freed (Figs. 32 and 34) dividing the blood supply. (Fig. 33.) The sigmoid is then crushed and divided with cautery (Fig. 35A) between two heavy silk ties. The bowel stumps are protected by rubber caps tied on with heavy silk. (Fig. 35B.) The proximal stump is then brought out of the abdomen for an end colostomy. (Fig. 36.) Following this, the pelvic peritoneum is reconstructed (Fig. 36B) and



the uterus, when present, is sutured back to reinforce this new pelvic floor.

Before suturing the abdomen we close the left lateral fossa by

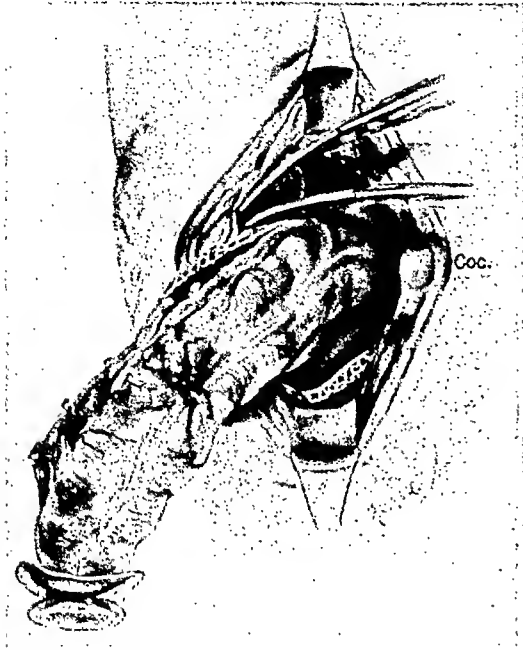


FIG. 42. To show wide lateral incision of levatores ani.

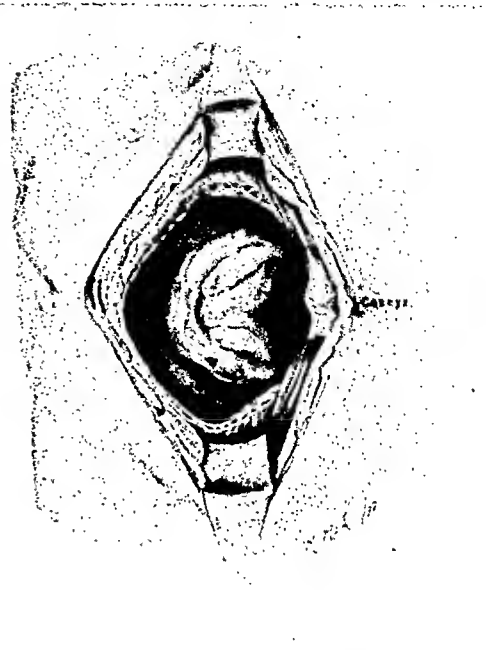


FIG. 43. Prostate and seminal vesicles seen in depths of wound.

approximating the lateral surface of mesosigmoid to the left lateral abdominal wall (Fig. 37) so that the small intestine cannot swing to the left of the sigmoid and thus down into the pelvis. We believe this an important prophylaxis against intestinal obstruction. The proximal stump of the sigmoid is now pulled through a split in the proximal third of the left rectus muscle. (Fig. 38.) The fascia is sutured loosely about the sigmoid. (Fig. 38c.)

In the perineal portion of this resection, we have been utilizing the Sims position for several years. The patient's blood pressure falls less in this position. The first step of the perineal is to effect a reinforced closure of the anus. A deep purse-string secures primary closure. (Fig. 39A.) Then an elliptical incision is made about the anus (Fig. 39B) and the skin securely sutured with a lock stitch. (Fig. 39C.) We believe this reinforcing maneuver is extremely important in reducing posterior wound sepsis. The coccyx is not removed routinely, though advocated by Miles and others. It is often not necessary in women because of the relatively large pelvic outlet; it is also omitted in men whenever possible. Resecting the coccyx adds definitely to postoperative discomfort. The rectum and lower sigmoid are now removed from below after freeing the perineal fat and sweeping it medially (Fig. 40), and after sectioning the levator



FIG. 44. Rubber covered gauze packed into  
posterior wound.

with several small gauze sponges protected at the proximal end  
with perforated rubber to avoid adhesion of the pack to the newly  
formed pelvic floor. (Fig. 44.)

#### THE JONES TWO-STAGE OPERATION

The first stage of this operation is as in the Miles, save that the sigmoid is not sectioned. Instead, the reectosigmoid is freed up as much as possible on all sides and is then dislocated downward into the pelvis as far as possible, with the peritoneum closed around it as high as possible. A loop of sigmoid proximal to the new pelvic floor is utilized for a colostomy.

At a second stage (seven to ten days later), the anus is closed and the rectum freed up from below, as in the Miles procedure, and then sectioned from below as close as possible to the pelvic floor which was constructed in the first stage.

The Jones operation is valuable in the older and moderately poor risk patient. It divides the operative procedure fairly evenly. It allows the patient's bowel function to become reestablished before resection is attempted. It relieves obstruction. Through the distal loop, irrigation can take place.

It is not a good operation for a high rectal or rectosigmoidal growth, as here the cancer is too near the newly formed pelvic floor for wide excision. Another disadvantage is that the operator is almost forced to do the second stage within ten days, as otherwise the bowel will become firmly adherent to the pelvis.

#### THE LAHEY TWO-STAGE OPERATION

In the first stage of the Lahey resection, the sigmoid is sectioned, leaving the proximal end as an end colostomy in the upper angle of the incision. The mesosigmoid is then divided down to the superior hemorrhoidal vessels, which are preserved. The distal bowel is brought out through a small stab wound. About two weeks later, an abdominoperineal resection is carried out. The bowel that has been implanted is closed and freed. The operation is then continued as in the Miles procedure. Our objection to the Lahey operation is that the two stages are not equally divided as in the Jones. Furthermore, it means entering the abdomen a second time and often working in a pelvis now containing edematous peritoneum and troublesome adhesions.

It is a good operation for (1) the moderately poor risk patient with a growth at or near the pelvic floor; (2) the patient with a rectovaginal perforation which must be cleared up before resection; and finally, (3) the patient who must wait a relatively long time between stages.

#### COLOSTOMY AND POSTERIOR RESECTION

It is unnecessary to discuss here the technique of colostomy and posterior resection, anterior resection, sigmoidal resection and end-to-end suture or Mikulicz. Lockhart-Mummery<sup>9</sup> states that colostomy and posterior resection are suitable "for growths situated in the ampulla and lower part of the rectum," and therefore can only be employed in less than one-third the cases. Moreover, this operation does not radically remove lymph nodes in the sigmoid mesentery. It is, however, the operation of choice with the squamous cell carcinoma of the anus. Here, of course, metastasis almost always takes place in the groins.

#### LOCAL EXCISION

In three cases a wide local excision was done. This operation is to be deplored because of the danger of both recurrence and metastasis. In these cases, it was used because the patients were extremely bad risks, and also because the tumors, clinically, were benign. The first

patient was a doctor. Low in his rectum there was a soft mass which was excised. The pathologist stated that he could not rule out beginning malignancy. Radium was therefore inserted in the operative area. The patient lived eight years without recurrence and then developed carcinoma of the lungs. At autopsy the pulmonary carcinoma was found to be metastatic from a recurrence in the sigmoid which had not been suspected.

The second patient had a soft growth, also low in the rectum. He in addition had an obstructing prostate, a large diverticulum of the bladder, and diabetes. The mass was excised and was reported as a malignant adenoma. The diverticulum and the obstructing prostate were later removed. He is living free from disease three and a half years since operation.

The third was a stout feeble lady of 82 with a small adenocarcinoma (Grade 11) of the rectosigmoid. It had a definite pedicle which was cut across and electrocoagulated. She is free from disease but only six months have elapsed since operation.

#### POSTOPERATIVE CARE

Vomiting and distention has been largely avoided by sharply limiting the oral fluid intake during the first four days after operation. Parenterally, however, 3,000 c.c. of fluid are administered in twenty-four hours, either 5 per cent glucose by vein or  $2\frac{1}{2}$  per cent glucose by hypodermoclysis. As the urinary output increases, the parenteral fluid is decreased. We endeavor to keep the urinary output at between 35 and 40 ounces in twenty-four hours. Under this régime, ileus is now rarely encountered. At the first sign of gastrointestinal block, we insert a tube into the stomach, and if there is retention we immediately attach the tube to a Wagensteen apparatus. In many instances this saves an ileostomy.

The colostomy is opened the morning following the operation, but it is not disturbed by irrigations if the patient is comfortable. We generally postpone colostomy enema for a week. The bowels in most cases move on the fourth or fifth day spontaneously. Oil by mouth can be given on the third or fourth day.

The posterior pack is removed on the fourth day, and after a week the posterior sinus is irrigated with half-and-half Dakin's solution and 4 per cent boracic acid.

We often get the patient up on the eighth or ninth day.

After the first two weeks, the patient frequently will stay clean between colostomy irrigations. If not, a low-residue diet is instituted. It is the rare patient that needs a colostomy bag. We discourage its

use, for it tends to make the patient careless concerning his colostomy régime, and the apparatus itself is invariably noisome.

Those interested in the postoperative care of colostomy are referred to an article on this subject, written by us,<sup>8</sup> in which the matter is discussed in detail.

Almost every patient can return to his former occupation without fear of social stigma or physical handicap. This series includes boilermakers and bankers, clerks, housewives, and officials.

#### CONCLUSIONS

1. At present, the therapy of choice for cancer of the rectum and rectosigmoid is the combined abdominoperineal resection in one stage.

2. In the hands of experienced surgeons, this operation can be utilized in approximately 75 per cent of the resections.

3. Whenever possible, borderline cases should be included among the resections.

4. In the hands of experienced anesthetists, spinal is the anesthesia of choice.

5. Routine postoperative transfusions should be employed.

6. The preliminary preparatory period should be extended to at least seven days.

7. A "team" is most essential in the treatment of every case. This team should include an experienced urologist.

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W. L. Keller	Washington, D.C.
H. A. Kelly	Baltimore
T. J. Kirwin	New York
Arthur Krida	New York
A. V. S. Lambert	New York
Maurice Lenz	New York
H. H. M. Lyle	New York
Jerome M. Lynch	New York
Urban Maes	New Orleans
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H. C. Naffziger	San Francisco
C. R. O'Crowley	Newark
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Eugene H. Pool	New York
Douglas Quick	New York
N. P. Rathbun	Brooklyn
H. A. Royster	Raleigh
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A. C. Scott	Temple
M. G. Seelig	St. Louis
J. Bentley Squier	New York
H. J. Stander	New York
H. L. Updegraff	Los Angeles
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## EDITORIALS

### KEEPING SURGEONS OUT OF COURT

**S**URGEONS find it extremely difficult to take vacations. Yet they are often forced to take time away from their patients and wait for hours, even days, to give legal testimony that ordinarily consumes but five or ten minutes. Aside from the possible danger to the lives of their patients through their absence, their practices suffer severely. Furthermore, any compensation which they may receive is hardly adequate for the loss sustained.

Surgeons might well organize to attempt to promote legislation similar to that which now exists in the federal courts, in order to keep them from the witness chair. In New York, a physician's certificate, properly sworn to, is accepted as evidence in compensation cases. It should be so in all cases—and in all states.

Physicians should be permitted to give their testimony at their convenience, in their own offices, before a notary public or commissioner of deeds, instead of having to make personal appearances in court. Attorneys should be permitted to cross examine at such examination. The procedure, in most cases, would not consume more than fifteen minutes and would not conflict with the surgeon's practice.

The profession could seek an amendment to the rules of evidence that would permit them to give their testimony on the foregoing basis. Surgeons should not be forced into court as professional witnesses in a controversy in which they have no personal interest, except to tell what they may know. No surgeon should be compelled to forsake the operating table for the counsel table.

MEYER KIRSCHENBAUM, Member of the New York Bar.



## ALLEN DEMING LAZENBY

1894-1939

IT is with regret that we announce the death on April 18th of Allen Deming Lazenby. He was 45 years old, had already behind him a notable career, and gave promise of even greater achievements.

Dr. Lazenby, a graduate of the University of Maryland School of Medicine and College of Physicians and Surgeons, was an outstanding worker in the industrial health field. He was one of the original members of the Council on Industrial Health of the American Medical Association, a Fellow of the American College of Surgeons and of the Association of Industrial Physicians and Surgeons. In addition, he was chairman of the Industrial Health Committee of the Medical and Chirurgical Faculty of Maryland; a member of the Medical Committee of the New York World's Fair, and vice-president and medical director of the Maryland Casualty Company. He had been a captain in the Medical Corps of the

United States Army, but had retired from active duty in 1919 for disability incident to the service.

Dr. Lazenby acted as Guest Editor of the Traumatic and Industrial Surgery Symposium published as the December, 1938 issue of The American Journal of Surgery. As a result of his efforts, his knowledge of the subject and his familiarity with eminent authorities in this field, this Symposium has become a standard text for physicians throughout the country and a work of reference invaluable to many lay agencies connected with the field of compensation, industrial and traumatic medicine.

Too young to go, yet during his short life Allen Lazenby had left the impression of his ability and personality in the sphere of his professional activity.

To his family, the Publisher and Editor of The American Journal of Surgery offer their deepest sympathy.

T. S. W.

## CORRECTION

Dr. Arthur Steindler wishes us to call attention to an inadvertent error in the labeling of Figure 3B of his article on "Tendon Transplantation in the Upper Extremity," page 268 of the April, 1939

issue. "Extensor carpi ulnaris" should have been "flexor carpi ulnaris"; "extensor carpi radialis" should have been "palmaris longus"; and "palmaris longus" should have been "flexor carpi radialis."

# ORIGINAL ARTICLES

## THE SURGICAL TREATMENT OF ESSENTIAL HYPERTENSION

PAUL G. FLOTHOW, M.D.

SEATTLE, WASHINGTON

THE etiology of essential hypertension is unknown. Without doubt there are many factors involved in its production. The endocrine glands and the sympathetic nervous system are certainly related in a definite manner in its production. It is well known that the thyroid, pituitary and adrenal glands all play an important part in production of vasomotor and vasopressor phenomena. It is probable that there are definite cerebral centers, perhaps in the diencephalon, which exert regulatory effects on blood pressure levels. Heredity and environment must play a further important part in the picture.

The importance of the study, understanding and hopeful therapy of this condition are little appreciated. By virtue of the fact, perhaps, that it has been so long considered a hopeless condition and one for which so little can be done, we have adopted a defeatist attitude toward the problem. Statistics of the Metropolitan Life Insurance Company show that four times as many people die annually in the United States from conditions in which hypertension is either the cause or a contributing factor that die from cancer. We have cancer clinics and associations for the study of and prevention of cancer, lay organizations for the control and early recognition of cancer, yet nothing similar is being done in the case of hypertension.

While the time has been too short to give authoritative statistics, various reports show that following surgical removal of various visceral nerves, from 25 to 50 per

cent of patients with essential hypertension have had blood pressure levels returned approximately to normal. This certainly compares very favorably with the results in the treatment of cancer.

There are four schools of thought regarding the surgical attack upon essential hypertension, namely, those of the Mayo Clinic, Peet, Crile and Heuer.

In general it may be said that all of the men engaged in this type of work agree that it is far from being a satisfactory answer to the problem of treatment of this condition. The concensus of opinion is, that while it cannot be considered a cure, it is at this time by far the most effective method of treatment, and the work should continue until some better form of therapy is found.

The viewpoints of the surgeon and the internist differ somewhat as to the value of this method of treatment. Internists who have seen only the occasional, and frequently the unsuccessful, case are very free with their criticism of the procedure. Surgeons who have done a great deal of this work, while not entirely enthusiastic about the results, are unanimous in feeling that their results render the continuation of this work well worth while. Strangely enough, some of the most enthusiastic supporters are internists in institutions where work of this kind is being carried on: men who have had opportunity of seeing the patients before and after surgery and of following the postoperative results.

The reviewer has recently visited the Mayo Clinic, the Cleveland Clinic and the

## Flothow—Surgery in Hypertension

University Hospital at Ann Arbor, three centers where a great deal of the work in this country has been done. He has interviewed both the internists and the surgeons, has inspected the case reports, the follow-ups and the statistical reports of the results of the various types of surgery. It has been an amazing observation that regardless of what the surgical approach has been, and almost regardless of the manner of selection of cases, the results have been very similar in these three different institutions.

The manner of selection of cases varies at each institution. In one a great deal of attention will be paid to a particular point as a criterion of suitability for operation, while in another it will be an entirely different one.

The results are certainly good enough to warrant the continued application of visceral nerve surgery in selected cases of hypertension.

## METHOD OF SELECTION

Cases are very carefully selected. They are usually selected by the internist and not by the surgeon. The preoperative studies are made on the medical side, and the internist determines whether or not the neurosurgeon should be offered the case. Very careful preoperative studies are carried out. These include the following:

1. Careful examination of the heart including electrocardiographic studies, x-rays and clinical examination.
2. Careful tests of kidney function, including all of the well-known tests, particularly the concentration test.
3. Careful determination of blood pressure levels with hourly determinations for a period of at least forty-eight hours.
4. The determination of the effect of large doses of sodium amytal or nembutal upon the blood pressure levels.
5. The effect of sodium nitrite on the blood pressure levels.
6. The cold test.
7. The intravenous pentothal test.

The age of the patient, the condition of the blood vessels and the duration of

symptoms and rapidity of progress are also taken into consideration.

Marked cardiac damage is a contraindication to surgery. However, many patients with essential hypertension show a certain amount of cardiac damage, and it becomes the task of the internist to determine whether this damage is irreparable. Some patients in whom serious heart complications are present have shown tremendous improvement after operation. The estimation of whether or not cardiac function will improve is a very difficult one, and rather severe cardiac damage should not absolutely contraindicate the operation, if other factors are favorable.

Severe kidney damage with marked reduction of renal function serves in most cases to contraindicate operation. However, the various tests of renal function do not tell the entire story. Peet believes the concentration test is of great importance and feels that if the kidneys are unable to concentrate the urine, operation offers very little hope. When other tests of kidney function such as the various protein tests and the P. S. P. test show marked reduction of function, but the kidney is still able to concentrate the urine, he feels that the kidneys are better than is apparent from the other tests. The presence of albumin apparently is not of great significance in regard to actual kidney function.

Allen and Adson<sup>2</sup> make the following statements: "We do not consider apparent sclerosis of the retinal arteries, moderate enlargement of the heart, inversion of the T-waves in the electrocardiograms, albuminuria, slight reduction in renal function or cerebral vascular accident from which recovery has been satisfactory, contraindications, in themselves, to operation. However, we do not advise operation for patients who have congestive heart failure, marked renal insufficiency, advanced arteriosclerosis, or angina pectoris."

While the determination of preoperative blood pressure levels is carried out in all institutions, some pay much more attention to this factor than others.

The effect of sodium amytal, 9 to 12 gr. (0.58 to 0.77 Gm.) or more, or nembutal in sufficient quantities to insure the patient's sleeping through the taking of blood pressures, is considered of considerable importance. Suitable cases should show a marked drop in the resting blood pressure levels, and it has been the reviewer's experience that the final postoperative blood pressure levels very closely approximate the resting figures.

Sodium nitrite given in  $\frac{1}{2}$  gr. (0.03 Gm.) doses, repeated every half hour for three hours, should have an appreciable effect in lowering the blood pressure to a basal level.

The cold test is performed by having the patient immerse the hand up to the wrist in ice water to which salt has been added to bring the temperature to  $4^{\circ}\text{C}$ . Several blood pressure readings are taken immediately before placing the hand in the ice water to determine the mean pressure. One hand is then immersed and the blood pressures taken every half minute for from two to ten minutes. The hand should be kept in the water for one minute if possible, but some patients cannot bear it more than thirty seconds. A response of increase in blood pressure of not over ten points is considered normal; from ten to twenty points slightly abnormal, and anything above this a markedly abnormal reaction. In some cases the systolic blood pressure may rise as much as fifty points as a result of the immersion of the hand in cold water. It is felt that this reactive rise in blood pressure indicates the relative importance of vasoconstriction as a factor in the individual case, and the higher the rise in the systolic pressure, the more favorable is it considered as an index of the suitability for operation.

The intravenous pentothal sodium test may be considered as the reverse of the cold test. It is felt that where nerve impulses play an important part in the production of elevated blood pressures, abolition of these impulses by an intravenous anesthetic such as pentothal sodium should result in a marked fall in the blood pressure levels. It would appear, therefore, that a patient

who demonstrates a marked fall would be a suitable one, whereas one in which the fall was slight should most certainly be unsuitable.

The test is simply performed, it being merely a matter of establishing the patient's blood pressure in a fixed position, preferably sitting or lying in bed, and then slowly administering the solution until the patient has completely lost consciousness. The blood pressure levels are determined at frequent intervals during this process until the patient regains consciousness, or until the blood pressure returns to the original level. It is felt that perhaps the blood pressure at the depth of complete unconsciousness is the basic level for that individual, and it could not be hoped that an operation would produce a lower sustained level.

Allen and Adson<sup>2</sup> state that incomplete studies indicate that pressure on the carotid sinuses may affect blood pressure to much the same degree that rest, amytal, sodium nitrite and pentothal affect it.

The age of the patient undoubtedly is of great importance, and, in general, the younger the patient, the better the possibilities. Some institutions established 40 as a maximum age earlier in their work, but now they have raised it to approximately 50. Crile does not feel that age is important, or rather, he feels that age does not necessarily contraindicate operation. He regards the degree of arteriosclerosis as much more important than the age of the individual. Most authorities believe that 50 years is just about the maximum age, and that patients over that age offer very little chance of improvement.

Any marked degree of arteriosclerosis is universally felt to be a definite contraindication to surgery.

There seems to be no uniformity of opinion regarding the importance of duration of symptoms and rapidity of progress. In general, it may be stated that most authorities are of the opinion that cases in which hypertension has been present a relatively short time and has progressed rather rapidly, are less favorable than those

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of many years' standing with a relatively slow rise of pressure levels. Those of very short duration with a very rapid rise in blood pressure levels usually are in the very malignant stage when first seen, and are, therefore, unsuitable.

The presence or absence and the degree of changes in the retinal arteries and optic discs are considered very important. Early retinal changes and minor degrees of spasm of retinal vessels can be determined only by skilled ophthalmologists versed in this particular field. Retinal changes severe enough to be noted by the occasional observer, frank choking of the optic discs, or retinal hemorrhage, are all evidences of malignancy, and indicate that the chance of surgery being of value is rather remote.

The reviewer believes that the entire future of this field of surgery is dependent upon the proper selection of cases. It is absolutely necessary that definite criteria of selection be established by means of which we may accurately select cases and foretell the approximate results.

The major purpose of the visits to the before-mentioned Clinics was to determine whether or not such criteria had been, or could be established. It is unfortunate, indeed, that one must report that at the present time this cannot be done. There are two broad methods of error. First of all, even though all of the tests may indicate that a case is highly suitable for surgery, yet the best we can hope for is just a little better than a 50 per cent chance of a good result. On the other hand, occasionally a case that would seem to be absolutely hopeless from the standpoint of these tests when operated turns out to have an excellent result. Therefore, it becomes impossible to determine accurately either one way or the other whether a case is suitable or unsuitable, or what our final result will be.

This much may be said, however. The chance of a good result in a patient who responds poorly to all or most of the tests is minimal. Operations in this type of case should rarely be undertaken. If we could be as accurate in determining which cases should be done as in determining which

should not be done, our percentage of good results would be greatly increased.

The reviewer has made certain observations and has come to noteworthy conclusions regarding the selection of cases for operation. It has been our experience in a limited number of cases, just as it has been the experience of all others engaged in this line of work, that the "batting average" in any one test as compared with the final result is not much better than 50 per cent. We feel, however, that the determination of resting blood pressure levels offers a very accurate index. The patient whose blood pressure level does not fall at night when determinations are made without disturbing the patient, in our estimation offers a very poor subject for a good result following surgery regardless of what the result may have been of any of the other tests. We feel that this affords an accurate index of the effect of nervous and vasomotor impulses on the blood pressure.

The cold test may produce a marked rise, but does not indicate what may be expected in regard to a fall in blood pressure.

The intravenous pentothal test introduces a profound chemical reaction, the effect of which may be such upon the central nervous system as cannot be approximated by surgery.

It has been our observation that those cases that did not show a fall in resting blood pressure levels have shown no appreciable fall postoperatively, and we, therefore, hesitate very much to advise operation in cases of this type regardless of what the other tests may show.

## CAUSES OF HYPERTENSION

It is well to call attention to the fact that there are conditions other than essential hypertension which may produce high blood pressure. The following classification is taken from Adson and Allen:<sup>2</sup>

1. Primary or essential hypertension. Estimated 85 per cent of all cases.
2. Secondary hypertension due to known disease. Estimated 15 per cent of all cases.

- (a) Coarctation of the aorta.
- (b) Glomerular nephritis.
- (c) Tumors of the suprarenal glands.
- (d) Hyperthyroidism.
- (e) Arteriosclerosis.
- (f) Traumatic arteriovenous fistula.
- (g) Aortic heart disease.

Essential hypertension may be roughly divided into three classes:

1. Chronic, which is slowly progressive, many years elapsing before it becomes malignant.

2. Subacute in which there is a comparatively short history and only a few years elapse from onset to malignant changes.

3. Acute in which the condition is rapidly progressive and probably is either malignant from onset or rapidly becomes so.

Blood pressure levels are not necessarily the criterion of malignancy, but kidney, cardiac and retinal damage are so considered. Some cases in Group 1 do not need surgery. Many of the cases in Group 2 are suitable for surgery, but only a few in Group 3.

The entire question of operating for hypertension can be likened to that of operation for cancer of the stomach, for example. Most cases of cancer of the stomach are inoperable when discovered as far as a reasonable chance of cure is concerned. No one would think of criticizing a surgeon for exploring a cancer of the stomach if there was any hope of cure or even palliation, yet these same individuals will throw up their hands in "holy horror" when an operation for hypertension is proposed, notwithstanding the fact that the results are not even comparable either from the standpoint of cure or palliation, and hypertension is just as deadly as cancer of the stomach.

Since we adopt heroic measures in one fatal condition, why condemn heroic measures in another where the chances of benefiting the patient are infinitely better?

#### SURGICAL TECHNIQUES

*Supradiaphragmatic Approach.* In this operation the splanchnic and sympathetic

nerves are resected above the diaphragm. The question of whether or not this is the proper or a superior approach depends upon the determination of whether or not fibers from the first and second lumbar sympathetic ganglia play any part in the product of elevated pressures. Peet<sup>4</sup> states that they do not. The Mayo Clinic group<sup>1,2</sup> feel that they play an important part in the innervation of the blood vessels of the kidney and it is, therefore, necessary that they be removed.

As far as the nerve supply to the celiac ganglion and plexus is concerned, Peet's operation is entirely preganglionic, and, if the same thing is true in this instance as has apparently been proved to be the case in Raynaud's disease, this approach theoretically should be the most favorable. It has a further advantage in that both sides can be done at one operation. Its theoretical disadvantages are the inability to denervate the first and second lumbar ganglia and the fact that the fibers of the aortic plexus coming through the diaphragm with the aorta, which may play a considerable part in the production of vasospastic phenomena, are not interrupted. It has the further disadvantage that the adrenal glands may not be explored and the occasional case of tumor of the adrenal glands may be overlooked.

It has not been determined whether or not a preganglionic operation is superior to a postganglionic operation in the case of hypertension. The final determination must come after a period of years and a careful comparison of results.

*Adson-Craig Type of Operation.*<sup>1</sup> The technique of this operation has been described frequently. It consists of a subdiaphragmatic approach with or without the removal of a portion of the twelfth rib, the removal of the major, minor and least splanchnic nerves, and a portion of the celiac ganglion. In addition to this the first and second lumbar ganglia are removed and the dissection carried up into the diaphragm from below. Recently, they have at times been removing the entire celiac ganglion. Previously, a portion of the

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adrenal gland was removed, but they have abandoned this procedure, being content to explore the adrenal glands to determine the presence or absence of a tumor.

The disadvantages of this operation are that it must be done at two stages, and that it is a considerably more difficult surgical procedure than that of Peet's. This operation is somewhat a hybrid, part of it being pre- and part of it being post-ganglionic. If the entire celiac ganglion is removed, it becomes a truly postganglionic operation, and as before stated this offers a theoretic disadvantage. It is apparently definitely safer than the Peet operation, a large number of these cases having been done at the Mayo Clinic without any deaths, whereas in Peet's series there has been a mortality of approximately 4 per cent.

**Crile Operation.** This may be considered a modification of the Adson-Craig operation. A small incision just large enough to admit the hand is made in the flank just below the twelfth rib, carried forward and downward into the retroperitoneal space. He identifies the celiac ganglion by sense of touch, places a hook on it and removes the ganglion by cutting against his finger with a long scissors, and at no time visualizes the structure involved. In addition to this he states that he denervates the adrenal gland with his finger. The lumbar sympathetics are not disturbed, and the various structures are not individually identified.

The advantage of this operation is the rapidity with which it may be done. Its disadvantage is that it may very readily be incomplete as far as denervation of the celiac plexus is concerned. In Crile's hands it is apparently an excellent operation. It is doubtful, however, that other surgeons could perform it with equal success. He has done a large series of cases, approaching one hundred, without a death, although previous to that series he had several deaths.

**The Intradural Section of the Anterior Root Components of the Splanchnic Nerves (Heuer<sup>5</sup>).** This operation requires a sec-

tion of all the anterior roots from the fifth dorsal to the second lumbar, thus necessitating a very long laminectomy, and while the results in some of these cases have been excellent, the magnitude of the surgical procedure offers its greatest disadvantage.

The reviewer has performed a modification of the Adson-Craig operation starting with his first case, namely, the removal of the entire celiac ganglion, and recently section of the aortic plexus medial to the ganglion. This is entirely a postganglionic operation and the reviewer feels that it accomplishes complete denervation of all vasomotor fibers on the postganglionic side. In all other respects the operation is exactly the same as the Adson-Craig operation, the rib being rarely removed. There have been no surgical deaths.

## RESULTS OF SURGERY

It is quite amazing that regardless of the type of operation performed, all of the groups report approximately the same results, namely, about 50 per cent good results and 50 per cent poor. Among those classed as poor, there are approximately half who receive clinical and symptomatic improvement even though their blood pressures are not affected.

The Mayo Clinic reports 25 per cent excellent results, 30 per cent good results, and 45 per cent poor results. Of the 45 per cent poor results approximately one-half show symptomatic improvement.

Peet's<sup>4</sup> results are very similar to those of the Mayo Clinic. The two institutions have about the same number of cases, and the results measured from all standpoints are almost parallel.

Crile's results are rather difficult to evaluate since he uses the decrease in diastolic pressure as his criterion of results and disregards the systolic pressure, while other clinics use the drop in systolic pressure as their basis. On the whole, however, his percentage of success is about the same as the preceding.

In a recent report from the Lakeside Hospital<sup>7</sup> a series of twelve cases were



reported in which Heuer's operation had been done, most of them with poor results.

### RESULTS

A statistical analysis of our own results is of necessity rather difficult by virtue of the type of cases submitted to operation. Twenty-two are included, the others being too recent to evaluate.

When we first started this procedure we operated on patients whom we would not consider as subjects now. In fact, in the past year more cases have been refused than accepted. Of the twenty-two, eight were in the definitely malignant stage, and at present at least five of these would have been refused. Two of these five have had results which justified surgery. Two others would have been refused because of their age. One has had a good result, and the other has since succumbed.

The cases will be considered first in two groups, and then as a whole to demonstrate our percentage of success. In the first group are ten cases which, due either to malignancy of disease or the age of the patient, would be questionable cases, and at least five of them would not be considered for surgery at the present time. Four of these ten have since died of their disease, and one of postoperative pneumonia following a hysterectomy. There have been no deaths attributable to the operation in the entire series. Two of the five survivors in this group have exhibited marked reduction of their blood pressure levels, two have been remarkably improved clinically without marked drop in pressure, and one has had no improvement either in clinical symptoms or in pressure levels. Two cases, or 20 per cent of the ten in this group have had marked reduction in blood pressure levels, and two cases, or 20 per cent, have been markedly improved clinically which makes a total of 40 per cent in which surgery has proved beneficial.

One of the cases in this group is particularly noteworthy. The patient was a woman 51 years old with a fifteen year

history of blood pressure above 200 which was gradually mounting. When first seen she had been bedridden for five months because of severe headache and palpitation on the slightest exertion. Her resting pressure was 300 plus systolic, and 156 diastolic. There was definite cardiac and kidney involvement, and she was in the last stages of her disease. Intravenous pentothal sodium dropped the systolic pressure from 285 to 185. Both patient and family requested operation in spite of the poor prognosis. She made an excellent recovery, and within three months was doing her own housework, and was practically free of symptoms except when she overexerted herself. She continued in excellent health for over two years with her blood pressure ranging between 190 and 225 systolic. Within the past month, after a long period of overwork, she has again flared up with a pressure of 285, and return of many of her previous symptoms, although she is still clinically considerably better than she was before the operations. This patient would undoubtedly have expired long ago had she not been operated upon.

Of the twelve patients in the second or definitely favorable group both as to age and diagnostic results of the various tests, there are six who have exhibited marked sustained falls in pressure, and six who have shown little or no fall in blood pressure, but have had marked clinical improvement. Fifty per cent of these cases are, therefore, classed as very successful, and 50 per cent as moderately successful. In the entire group the result has been satisfactory, and the operations have proved well worthwhile in all the cases as far as the patient is concerned.

Eight patients in the entire series of twenty-two, or 36.3 per cent, have shown marked sustained falls in blood pressure levels. Eight, or 36.3 per cent, have shown little fall in blood pressure levels, but a marked clinical improvement. The remaining six cases, or 27.4 per cent have been classed as failures. Five of these six cases were in the unfavorable group which would



not be accepted for operation at the present time.

Too frequently opinions as to the value of this treatment are based upon the observation of those cases which might be classed as failures by reason of the fact that their blood pressures are not materially lowered. Those of us doing this work, however, cannot be convinced that it is not of value since we have all had experience with cases in which the results have been excellent.

In all of the author's cases it has been almost invariably true that the patients have been clinically and symptomatically markedly improved regardless of the effect on blood pressure readings. We have come to the conclusion that the results of the operation cannot be measured by manometric blood pressure determinations, and that many cases, which for purposes of statistics are classified as fair or poor results, should not be so classified. We feel that the operation produces results upon factors in the underlying causes and the associated effects of hypertension which we have no means of measuring.

One case may be cited as an example of such effects. A man, age 32, who had been discharged from the Navy because of hypertension and the fact that he was suffering from severe headaches, shortness of breath, fatigability, etc., desired operation. All of the preoperative diagnostic tests indicated that his should be an unfavorable result, and he was advised against the operation. He insisted upon it, however, and offered himself as an experimental case. Before he left the hospital his blood pressure was 260/160 which was exactly the same as his preoperative levels. Four months later this man came in stating that he felt as well as he ever had in his life, and asked for a letter to the Navy recommending reinstatement. He said that he could do as good a day's work as he had ever done, and that he had no complaints or symptoms. His blood pressure was still 260/160. His eye grounds, which had showed hemorrhages before, were entirely

clear, and in every way except for his blood pressure readings this man was perfectly well.

One thing seems quite certain; namely, that even though postoperative pressure may approximate preoperative pressures, the extreme pinnacles of pressure that had occurred before have been eradicated, as well as many or all of the subjective symptoms of the disease.

Since there is no other type of treatment which offers results in any way comparable to that of the surgical treatment, the work should certainly be continued, and perhaps as time goes on, definite criteria may be evolved for more accurate selection of cases so that failures will become less and less frequent.

#### SUMMARY

The various tests made to select suitable cases of essential hypertension for surgical treatment are described and their value discussed.

An attempt is made to indicate the proper cases for operation, and the indications and contraindications set forth.

The various operative techniques are described and their advantages and disadvantages discussed.

The results of the various types of surgery and of the groups doing this work are reported. Individual groups report similar results. Excellent results are reported in 25 to 50 per cent, and worthwhile results in over 50 per cent of cases by all groups. In addition all reports show a marked improvement clinically without fall in blood pressure in approximately another 25 per cent of cases.

The author reports 36.3 per cent excellent results, 36.3 per cent good results and 27.4 per cent failures in a series of twenty-two cases.

#### CONCLUSIONS

The surgical treatment of hypertension has now been practiced long enough to

prove that it is of great value in a selected group of cases. When cases are carefully selected, surgery offers at least an even chance of proving markedly beneficial.

As time goes on and criteria of selection become more accurate, the percentage of successful results should be markedly increased.

There is no other method of treatment of essential hypertension that offers anything even comparable to the results following extensive sympathectomy. Without doubt life can be prolonged and many patients markedly benefited by surgical procedures in essential hypertension.

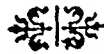
Postoperative blood pressure cannot be the only criterion of results accomplished since many patients who exhibit no fall in blood pressure are markedly improved clinically and symptomatically.

The various objections that have been made to the operative treatment of essential hypertension are well answered by Allen and Adson.<sup>6</sup>

Only time will answer the question of whether or not the operations result in permanent cure, but there is no doubt as to their value in many cases of several years' duration.

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# HYDATIDIFORM MOLE\*

## WITH ANALYSIS AND FOLLOW-UP OF TWENTY-FOUR CASES

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**A**TYPICAL hydatidiform mole consists of a mass of translucent, grape-like vesicles, arranged in stalks, similar to beads on a string. The vesicles contain a clear, viscid substance and vary in size from the microscopic to about 3 cm. in diameter. They result from the degeneration of chorionic villi, so that each stalk represents what was once a villus. This peculiar formation usually occurs early in pregnancy when the ovum is surrounded by chorionic villi. Ordinarily it involves the entire periphery of the chorionic membrane but at times is limited to portions of it.

### HISTORY AND PATHOLOGY

It is generally stated that the condition was first described by von Graefenberg in 1565, but it has since been pointed out that Aetius of Amida, in the early part of the sixth century, wrote intelligently about hydatidiform mole, although he seemed to have no clear idea as to its true nature.

As the name implies, many of the early writers considered the condition analogous to the echinococcus or hydatid cysts observed in other parts of the body. Some held that the vesicles were mature ova; others that they were multiple embryos.<sup>1</sup> It was not until the nineteenth century that the true nature of the lesion was finally recognized.

In 1895, Marchand<sup>2</sup> demonstrated that the essential lesion was to be found not only in the stroma, but in the trophoblastic epithelial covering of the villus—the syncytial and Langhans layers. He showed that both layers undergo profuse and irregular proliferation, deeply invading Nitabuch's fibrin layer into the decidua and occasionally into and through the uterine musculature. This increase in the cellular

activity of the trophoblast probably accounts for the penetration of maternal tissues, which, in normal pregnancy are not invaded.

While the trophoblast is undergoing proliferation, the blood vessels of the terminal villi are obliterated and disappear. The stroma cells degenerate and their nuclei lose their staining reaction. The stroma is replaced by a central cavity filled with fluid which has the characteristics of edema fluid rather than mucin. In consequence of this proliferation and stroma change, the resulting mass of tissue frequently reaches the size of a five months' gestation.

In his original article, Marchand<sup>2</sup> stated that in many instances of hydatidiform mole, the ovaries are the seat of cystic changes. These changes have also been noted by other observers. In some instances, one or both ovaries may become converted into polycystic tumors, attaining a diameter of from 10 to 15 cm. The component cysts vary from a few millimeters to 5 or 6 cm. in diameter. They are lined by lutein cells and are filled with a clear content. Although lutein cell cystomata occur fairly often in cases of hydatidiform mole, they are not a universal accompaniment of the condition. Bland<sup>4</sup> and Findley<sup>3</sup> report their occurrence in 1.5 and 11 per cent of the cases respectively, while only one of Williams' cases showed this complication.<sup>4</sup> Novak<sup>4</sup> believes that they probably are always present, but are often overlooked during routine examination, especially when very small. Most authors are of the opinion that these cystic changes represent an exaggeration of theca lutein proliferation which occurs in normal pregnancy. It is generally thought

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that they are due indirectly to the action of the proliferating trophoblast on the anterior lobe of the pituitary body. These cystoma undergo spontaneous involution within a few months after expulsion of the mole.

#### ETIOLOGY

The etiology of hydatidiform mole is unknown. Multiparity and endometritis may play a part in its causation.<sup>5</sup> It is undoubtedly a process that originates in the ovum, rather than in the maternal tissues, for in several recorded instances of twin pregnancy, one ovum was normal, while the other was the seat of a hydatidiform mole.<sup>5</sup>

#### INCIDENCE

It is generally taught that hydatidiform mole is a rare disease. According to Madame Boivin,<sup>4</sup> it occurs once in 20,000 cases. Later authors feel that it is of more frequent occurrence. Storch,<sup>4</sup> in a series of unselected, abortive ova, found that 75 per cent showed some evidence of hydatidiform change. Meyer<sup>6</sup> notes hydatidiform degeneration of varying degree in from 4 to 10 per cent of all pregnancies. He noted evidence of it in 42.3 per cent of all extra-uterine pregnancies and in 32.4 per cent of uterine abortions. Gordon,<sup>4</sup> in analyzing 4,500 abortions at Bellevue Hospital, observed twenty-one cases, an incidence of 1 in 214. Velasco<sup>4</sup> noted its occurrence once in 204. Allen<sup>7</sup> states that it is the most common disease of the placenta and considers its incidence as about 1 in 300. The condition is probably much more frequent than is usually thought, because early hydatidiform changes may be overlooked by the clinician and even by the pathologist. According to Findley,<sup>3</sup> who presented a collective review of 500 reported cases, *clinically noticeable* hydatidiform mole occurs once in 728 pregnancies.

As to age incidence, it is essentially a disease of the active child-bearing period, that is from 20 to 35 years.<sup>4</sup> As to parity, it is much more common in patients who have previously borne children. A normal

pregnancy following hydatidiform mole is quite common, while recurrence in subsequent pregnancies is rare,<sup>5</sup> it having been noted in less than 1.5 per cent of the cases.<sup>3</sup>

#### SYMPTOMS AND SIGNS

Hydatidiform mole is usually observed in the first trimester of pregnancy. Its chief symptoms are vaginal bleeding and rapid enlargement of the uterus out of proportion to the period of gestation. In some cases, abdominal pain, hyperemesis<sup>8</sup> or symptoms of pre-eclamptic toxemia with edema, hypertension and marked albuminuria may be present. If the growth extends through the entire wall of the uterus, symptoms of perforation and internal hemorrhage will occur.

The bleeding gives rise to a pale red or brown vaginal discharge, which often is watery in character. Profuse hemorrhage is unusual until the mole is expelled, at which time it may be alarming.

The enlargement of the uterus may be quite marked, although at times the uterus is unchanged or may even be smaller than would be expected. The latter is especially true if the patient is not examined until the second or third trimester. Thus, in a patient three months pregnant, the uterus may extend to or above the umbilicus. Owing to the absence of the fetus and liquor amnii, no ballottement is obtainable and probably for the same reason, the uterus has a peculiar, boggy consistency.

#### DIAGNOSIS

Fetal movements and fetal heart sounds are absent. The Aschheim-Zondek (Friedman) test is markedly positive. Vaginal examination reveals the bloody discharge and the enlarged uterus with its unusual consistency. One or both ovaries may be enlarged and cystic. Eventually, the mole is expelled spontaneously and then a few grape-like vesicles are discharged with bleeding. When vesicles are felt or seen, the diagnosis becomes certain.

#### PROGNOSIS

*Fetal Prognosis.* As a rule the embryo dies and is absorbed.

**Maternal Prognosis.**

According to Bland,<sup>4</sup> one patient out of every eight or ten dies from hydatidiform mole either directly, as a result of hemorrhage, sepsis, perforation with peritonitis, or indirectly, as a result of chorionepithelioma.

Dorland<sup>4</sup> noted an immediate mortality of 10 per cent in a series of 100 cases which he collected from the literature. Three per cent died from hemorrhage, 2 per cent from perforation, and 5 per cent from sepsis. Findley,<sup>3</sup> in his analysis of 500 reported cases, gives a total mortality of 22 per cent: 4 per cent from hemorrhage; 2 per cent from perforation and sepsis, and 16 per cent from chorionepithelioma.

Figures as to the relation of chorionepithelioma to hydatidiform mole are very unsatisfactory and many writers are at variance on the subject. Bland<sup>4</sup> thinks that it is highly probable that malignant disease of the chorion rarely, if ever, occurs without preceding hydatidiform mole, although hydatidiform degeneration may not be recognized or even suspected. Findley<sup>3</sup> found that hydatidiform mole was followed by chorionepithelioma in 31.4 per cent of cases. His figures are from reported cases and as Mathieu<sup>23</sup> points out, the incidence would be higher in a group of reported cases than in an unreported series. Mathieu,<sup>23</sup> in a recent report of 127 cases, found mole followed by chorionepithelioma in twelve patients (9.4 per cent). Schumann<sup>10</sup> teaches that 10 per cent are followed by chorionepithelioma. Novak<sup>4</sup> feels that only 1 per cent are followed by chorionepithelioma. De Lee<sup>5</sup> has never seen a case of mole followed by chorionepithelioma. Symmers,<sup>5</sup> in a follow-up of eighteen cases of hydatidiform mole, found no cases of chorionepithelioma.

**TREATMENT**

It is universally agreed that the uterus should be emptied as soon as a diagnosis of hydatidiform mole has been made. Delay may result in hemorrhage, perforation or sepsis.

The cervix should be dilated sufficiently to admit two fingers, and the growth peeled off the uterine wall, using great gentleness

to avoid possible perforation. For the same reason, no curette or sharp instrument should be used. Following removal, the uterine cavity should be thoroughly iodinated. It is important that the growth be completely removed because retention of vesicles may lead to sepsis or continued hemorrhage. Some gynecologists prefer to empty the uterus by means of anterior vaginal hysterotomy. Schumann<sup>10</sup> advises abdominal hysterotomy followed by hysterectomy if necessary after examining the uterine wall. This seems to be a very radical procedure unless the patient is near the menopause or has had a number of children. If lutein cystomata are found, they should not be removed, for we know that they undergo spontaneous involution shortly after removal or expulsion of the mole.

After discharge from the hospital, these patients should be carefully observed because of the possible occurrence of chorionepithelioma. For many years it was taught that any woman who expelled a mole should be watched carefully for some time, and if hemorrhage or any anomalous bleeding made its appearance, the uterus was curetted and the scrapings subjected to microscopic examination by a competent pathologist. If chorionepithelioma was found, immediate hysterectomy with large doses of radium or x-ray was recommended. Cullen<sup>11</sup> and many others believe that a diagnosis of chorionepithelioma can not be made on curettings alone, and feel that a section of the uterine musculature must also be examined.

The Aschheim-Zondek (Friedman) test is of great value in the diagnosis of both hydatidiform mole and chorionepithelioma. While 1 c.c. of urine causes a positive reaction in normal pregnancy, the same may be obtained with  $\frac{1}{50}$  c.c. in hydatidiform mole and with  $\frac{1}{100}$  c.c. in chorionepithelioma, as has been reported by Castello,<sup>12</sup> Mazer,<sup>13</sup> Kimbrough, and others. They believe that the Aschheim-Zondek (Friedman) test should not be positive for longer than two weeks following a normal gestation, or eight weeks after the expulsion or

thorough operative removal of a mole. They feel that the presence of prolan in increasing concentration, longer than two weeks after a premature or full term pregnancy, is indicative of chorionepithelioma, and that the same is true when prolan persists for two months after a mole. Likewise, the reappearance of a positive test following one or more negative ones is pathognomonic of malignant degeneration.<sup>22</sup>

However, a case is reported by Falbusch,<sup>20</sup> in which the curettings led to a suspicion of malignancy. The Aschheim-Zondek test was negative; no operation was done, and the patient made a spontaneous recovery.

Balkow<sup>14</sup> states that the Aschheim-Zondek reaction is always positive in the presence of chorionepithelioma and considers it much more reliable than microscopic examination of the curettings. He feels that early diagnosis of chorionepithelioma by curettage is impossible. Leventhal and Sapir<sup>15</sup> observed that the Aschheim-Zondek test is a prognostic index in cases that have had a mole and, in the absence of clinical manifestations, the amount of gonadatropic substance in the urine in excess of 20,000 mouse units per liter indicates an early chorionepithelioma. Vozza<sup>16</sup> believes that the Aschheim-Zondek test should be done in all cases where chorionepithelioma is suspected. He feels that it is easier to establish a diagnosis by this means than by curettage.

Rosenstein<sup>17</sup> also shares this belief and suggests a course of procedure to be used in following cases that have expelled moles. He recommends that the test be done two weeks after the expulsion of a mole, and every two weeks thereafter until negative. It then should be repeated every four weeks for at least three months. He considers that a continued negative test during this time definitely rules out the presence of chorionepithelioma and notes that no exception to this statement is recorded. On the other hand, Schumann<sup>24</sup> recently reported a case in which curettings considered to be deciduitis were in reality chorionepithelioma. Two Aschheim-Zondek tests were

negative. He feels that the biologic tests, especially with high dilutions of urine, in the presence of persistent fetal elements, makes the diagnosis of chorionepithelioma practically certain. He also believes that when, under the same conditions, these tests remain negative, one cannot be sure that chorionepithelioma of lower proliferation and malignant quality is not present.

Mathieu<sup>23</sup> warns that there is a 2 per cent error in the Aschheim-Zondek (Friedman) test. With the use of immature rabbits, a false negative is more probable than a false positive test. Therefore, a negative test which does not agree with the clinical picture might be false, and the test should be repeated. He does not believe a true negative Aschheim-Zondek test can be obtained in the presence of living chorionic tissue. He feels that if, in following cases of hydatidiform mole, one obtains two or three negative tests (enough to avoid the possibility of a false negative), he may be sure that chorionepithelioma will not develop from that mole or pregnancy.

Cases have been reported by Outerbridge,<sup>18</sup> Reis,<sup>19</sup> and others<sup>22</sup> in which long periods of time elapsed between the occurrence of pregnancy or hydatidiform mole and chorionepithelioma. These latent periods have varied from one and one-half to twenty years. One case is reported in a woman 75 years of age, twenty years past the menopause. In none of these cases was the Aschheim-Zondek test done. The question arises: Do these cases result from surviving chorionic elements in the uterus, or are they metastases from some other structure such as a teratoma of the ovary?

Mathieu<sup>23</sup> noted that 80 per cent of chorionepitheliomata were found within twenty days after the passage of the mole, in those cases in which the patient was properly examined, in which sufficient Aschheim-Zondek tests had been made, and in which pathologic specimens were examined. This fact, plus his clinical experience, leads him to the hypothesis that certain cases of mole have the potentiality of malignancy. In these patients the malignancy is present with the mole—

JUNE, 1939

TABLE I  
ANALYSIS OF CASES  
LONG ISLAND COLLEGE HOSPITAL

HOSP. NO.	DATE	AGE	YRS. MARRIED	PREGNANCIES NO. & LABOR	L.M.P.	DURATION OF BLEEDING MOS. SINCE LAST REG. PERIOD	SIZE OF UTERUS	HEMATOLOGY	ALBUMIN	BLOOD PRESSURE	OTHER SYMPTOMS	OPERATION DIGITAL EVACUATION VAC. HYSTEROTOMY ABD. HYSTEROTOMY - HYSTERECTOMY	HOSPITAL DAYS	CHIEF CYSTIC SURVEILLANT HISTORY	PREGNANCIES NO. & LABOR	RECUR	WOUNDS	YRS. AFTER OPERATION	LAST SEEN CONDITION	A. Z.
4844 R.F.	1917	21	?	?	?	?	?	?	?	?	?									
2548 M.O.	1918	47	28	11	10	1	MAR. 1/18	8 WBS. 2 1/2	4 MOS.	NOT DONE	TRACE	185/103	NONE							
3168 R.L.	1918	40	24	3	3	0	JAN. 3/18	3 MOS. 1	3 MOS.	12200 WBC Hb 75%	NEGATIVE	153/98	NONE							
2582 P.3.	1919	23	3	0	0	8	OCT. 8/18	NONE	7	2 MOS.	10300 WBC Hb 80%	NEGATIVE	104/80	NONE						
2443 O.L.	1920	32	33	12	4	3	FEB. 1/20	1 MO. 3	3 MOS.	11300 WBC Hb 80%	TRACE	300/100	NONE							
4177 H.S.	1921	23	4	1	1	8	JULY 24/21	4 WBS. 2	4 MOS.	8200 WBC Hb 86%	TRACE	110/70	ABDOMINAL ENLARGEMENT							
4708 M.M.	1921	38	8	2	0	0	JULY 1/21	3 MOS. 1 1/2	3 MOS.	12200 WBC Hb 86%	4+ 8 GRAMS TO LITER	148/88	HYPEREMESIS TOREMIA							
4488 F.E.	1923	24	1	0	0	0	NOV. 14/24	2 MOS. 2 1/2	4 MOS.	8808 WBC Hb 84%	TRACE	100/80	NONE							
1476 M.R.	1923	32	7	3	3	0	JULY 28/24	2 MOS. 7	4 MOS.	7200 WBC Hb 84%	NEGATIVE	120/70	NONE							
8768 A.S.	1923	32	8	4	4	0	OCT. 11/23	2 MOS. 2 1/2	4 MOS.	12000 WBC Hb 82%	TRACE	130/80	LOWER ABD. PAIN							
1838 R.W.	1928	44	22	3	2	1	OCT. 21/23	1 MO. 4	3 MOS.	12400 WBC Hb 88%	TRACE	144/84	NONE							

TABLE II  
LONG ISLAND COLLEGE HOSPITAL

HOSP. NO.	DATE	AGE	YRS. MARRIED	PREGNANCIES NO. & LABOR	L.M.P.	DURATION OF BLEEDING MOS. SINCE LAST REG. PERIOD	SIZE OF UTERUS	HEMATOLOGY	ALBUMIN	BLOOD PRESSURE	OTHER SYMPTOMS	OPERATION DIGITAL EVACUATION VAC. HYSTEROTOMY ABD. HYSTEROTOMY - HYSTERECTOMY	HOSPITAL DAYS	CHIEF CYSTIC SURVEILLANT HISTORY	PREGNANCIES NO. & LABOR	RECUR	WOUNDS	YRS. AFTER OPERATION	LAST SEEN CONDITION	A. Z.
5372 C.V.	1927	34	8	3	3	0	MAR. 11/27	1 MO. 4	3 MOS.	11800 WBC Hb 80%	TRACE	112/80	LOWER ABD. PAIN							
1418 A.R.	1928	30	13	2	0	2	OCT. 20/27	1 MO. 4	2 MOS.	13800 WBC Hb 70%	NEGATIVE	110/70	LOWER ABD. PAIN							
4743 C.L.	1928	23	1	0	0	0	JULY 20/27	4 MOS. 8	3 MOS.	8200 WBC Hb 80%	NEGATIVE	113/83	NONE							
7255 M.C.	1931	30	11	3	3	0	JUNE 15/31	3 MOS. 3 1/2	4 MOS.	8250 WBC Hb 82%	NEGATIVE	100/80	NONE							
8484 E.C.	1932	24	4	1	1	0	MAR. 1/32	3 MOS. 8	3 MOS.	11830 WBC Hb 78%	NEGATIVE	110/72	NONE							
2011 J.S.	1933	31	3	0	0	0	SEPT. 24/31	4 MOS. 4	4 MOS.	9400 WBC Hb 83%	NEGATIVE	110/85	LOWER ABD. PAIN							
4422 S.O.	1933	33	12	4	2	2	JAN. 14/33	NONE	3 1/2	3 MOS.	Hb 80%	4+ 10 GRAMS TO LITER	TOREMIA							
4320 C.L.	1934	43	18	13	13	1	APRIL 25/33	2 MOS. 3	4 MOS.	1400 WBC Hb 88%	TRACE	120/78	NONE							
3803 A.M.	1935	27	1	0	0	0	FEB. 18/35	3 MOS. 3	8 WBS.	5050 WBC Hb 65%	NEGATIVE	108/88	HYPEREMESIS							
8842 A.R.	1936	33	8	3	0	3	MAR. 28/36	1 MO. 8	3 MOS.	10000 WBC Hb 70%	NEGATIVE	120/70	HYPEREMESIS							
3733 E.R.	1937	28	2	1	0	0	OCT. 9/38	2 MO. 4	3 MOS.	7400 WBC Hb 77%	NEGATIVE	110/80	NONE							

actual malignant changes have already taken place and even though the mole is passed or removed, the malignant cells remain.

During the twenty years from January 1, 1917, to January 1, 1937, twenty-four cases of hydatidiform mole were admitted to the gynecologic service of the Long Island College Hospital.

TABLE III  
AGE INCIDENCE 21 TO 52

Years	Cases	Per Cent
20-30.....	10	41½
30-40.....	10	41½
Over 40.....	4	16½

PARITY

Parity	Cases	Per Cent
Multipara.....	17	71
Nullipara.....	6	25
Not noted.....	1	4

TABLE IV  
ONSET OF FIRST SYMPTOMS

Months	Cases	Per Cent
2.....	3	75
2½.....	5	
3.....	2	
3½.....	3	
4.....	4	
5.....	1	25
6.....	2	
7.....	2	
9.....	1	
Not noted.....	1	

Aschheim-Zondek (Friedman) test was done on the urine of every patient but one (this patient was killed in an automobile accident ten years after expelling a mole).

TABLE V  
URINALYSIS

Albumin marked.....	3
Albumin trace.....	8
Albumin negative.....	11
Albumin not noted.....	2

HYPERTENSION

Present.....	9
Not present.....	14
B/P not noted.....	1

TABLE VI  
SIZE OF UTERUS IN RELATION  
TO PERIOD OF PREGNANCY

Size	Cases	Per Cent
Larger.....	11	45
Smaller.....	8	33½
Normal.....	4	16½
Not stated.....	1	5

TABLE VII  
SYMPTOMS OTHER THAN BLEEDING

Marked abdominal enlargement.....	1
Hyperemesis.....	3
Toxemia.....	3
Lower abdominal pain.....	4

TABLE VIII  
TREATMENT

Spontaneous evacuation.....	3
Digital removal.....	10
Digital removal with radium.....	1
Anterior vaginal hysterotomy.....	8
Abdominal hysterotomy.....	1
Abdominal hysterectomy.....	1

TABLE IX  
SUBSEQUENT PREGNANCIES

Cases sterilized or near menopause....	7
Cases in whom pregnancy was possible	17
Of these 17 cases 9, or 53 per cent, became pregnant and 8, or 47 per cent, did not conceive.	

TABLE X  
MORBIDITY AND MORTALITY

Morbidity (using as a standard 100.4°F. on two consecutive days excluding the first 24 hours)....	0
Maternal mortality—primary.....	0
Maternal mortality—remote.....	0

#### SUMMARY OF FINDINGS

1. An analysis of twenty-four cases of hydatidiform mole is presented.
2. Twenty patients (83 per cent) were under forty years of age.

We have been unusually fortunate in obtaining follow-up records on all of these patients, either by personal contact, or through other members of the hospital staff, who, as private physicians, were responsible for their care.

The follow-up data included the history as to general health, menses, and subsequent pregnancies. In addition, the



3. Seventeen patients (71 per cent) were multiparae.

4. Three patients (12½ per cent) had as initial symptoms, evidence of fulminating pre-eclamptic type toxemia, with marked edema, hypertension and albuminuria. It is noteworthy that the signs of toxemia were established before the end of the first trimester of pregnancy.

5. The uterus was enlarged out of proportion to the period of gestation in only eleven cases (45 per cent). However, all eleven cases were noted in women who were examined before the end of the fourth month of pregnancy. Patients examined after the fourth month showed the uterus to be about normal size or smaller than normal for that period of gestation.

6. Only two cases (8 per cent) showed cystic enlargement of the ovaries.

7. Twenty-two cases (over 91 per cent) were treated from below, while only two cases (8 per cent) were treated from above, both as a result of error in diagnosis. In one instance an abdominal hysterectomy was performed on a patient 47 years of age with a diagnosis of fibroid uterus. In the other case abdominal hysterotomy was performed for fulminating toxemia that did not respond to treatment, and in which hydatidiform mole was not suspected.

8. The good results following treatment from below seem to indicate that this method of approach is preferable to laparotomy, as suggested by Schumann and others.

9. One patient received 3,000 mg. hours of radium after digital removal of a partially retained mole. She was 44 years of age and had been treated in another institution six weeks prior to admission to the Long Island College Hospital.

10. Seventeen patients (53 per cent) subsequently became pregnant and were delivered of full-term normal infants. There was no recurrence of mole in any of them.

11. There was no morbidity in this series.

12. There was no mortality, either primary or remote.

13. Chorionepithelioma did not develop in any of these cases and Aschheim-Zondek (Friedman) tests done on the urine long after the expulsion or removal of the mole, failed to show evidence of surviving chorionic elements.

14. While this small series of cases undoubtedly should not be interpreted as a criterion of actual incidence, nevertheless, it seems to bear out the contention of Novak, Black, and others that hydatidiform mole is not followed by chorionepithelioma as frequently as is commonly thought.

15. It is understood that in advocating the management of these cases per vaginam, we still consider that the patient is to be observed for the occurrence of irregular bleeding and that the Aschheim-Zondek (Friedman) tests are to be repeated frequently during the first year following the expulsion or removal of a mole.

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# GRANULOMA INGUINALE (VENEREUM) IN THE FEMALE\*

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AUGUSTA, GEORGIA

*Definition.* Granuloma inguinale (venereum) is a chronic specific infection chiefly of the skin and subcutaneous tissues, and in the female primarily involves the external genitalia or the inguinal region. Less frequently the vagina or the cervix is the primary site of the disease. The causal organism is believed to be the Donovan body. The disease is probably venereal in origin and occurs most commonly in the colored race.

*Etiology.* It is generally accepted that the Donovan body is the causative agent. Several investigators, however, believe it is due to a bacillus belonging to the mucosus capsulatus group of Friedlander. McIntosh<sup>1</sup> claims to have grown this organism on various ordinary culture media, but this could not be substantiated by Dienst, Greenblatt and Sanderson<sup>2</sup> who have been unable to cultivate the Donovan bodies in spite of the fact that on several occasions they fortunately obtained the organism free from any type of bacteria from unruptured pseudo-buboes. They are convinced that the organism is not a bacterium. De Monbreun and Goodpasture<sup>3</sup> recovered the Donovan bodies from artificially infected monkeys. One of us (R. B. G.) has succeeded in transmitting the disease from one patient to another with recovery of the organism in a pure state from the inoculated person one month and two months afterwards.

The disease is thought to be venereal because the primary lesion most often appears on the genitalia, and only during the period of active sex life of its victims. Individual susceptibility, uncleanliness and race are important etiologic factors. It is possible that the disease may be transmitted by some insect vector, but this has never been proved.

*Pathology.* Pund and Greenblatt<sup>4</sup> summarize the pathology thus: "Granuloma venereum reveals in the pure or unmixed cases a uniform histologic picture. The essential features are (a) the massiveness of the cellular reaction in which the luxuriant granulation tissue is surcharged with plasma cells; (b) the relative and conspicuous paucity of lymphocytes; (c) the diffuse sprinkling of polymorphonuclear leucocytes, with focal collections in the superficies and papillae; (d) the pronounced marginal epithelial proliferation simulating early epitheliomatous changes; and (e) the pathognomonic large mononuclear cells scattered in various numbers throughout the granulation tissue. (Fig. 1.)

"The pathognomonic cell is specific for granuloma venereum. The relatively large size of the cell, the diameter of which varies from 25 to 90 microns, and the many intracytoplasmic cysts filled with deeply stained bodies are its cardinal features. Donovan bodies are round or rod-like and are grouped peripherally within the cysts

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and have an affinity for hematoxylin. (Fig. 1.) Their recognition is of paramount importance, for it permits the diagnosis of various manifestations in this phase is essential, for it is quite amenable to treatment and cure. A knowledge of the early

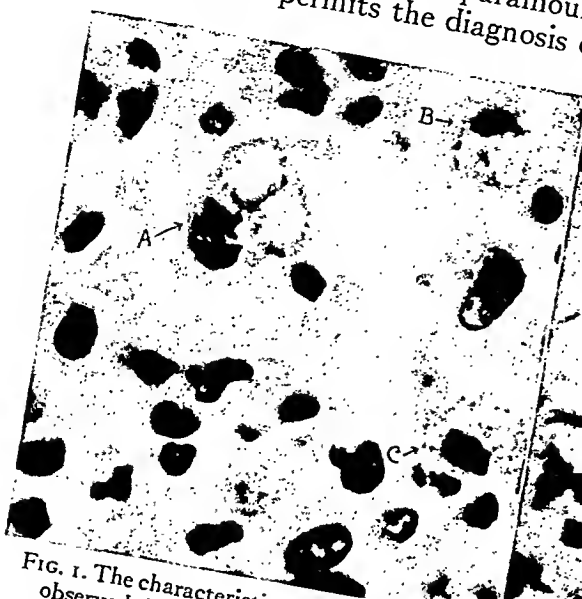


FIG. 1. The characteristic cellular response as observed in tissue section stained with hematoxylin and eosin. A, the pathognomonic cell is diagnostic of granuloma inguinale. Note the small rounded bodies lining the periphery of the intracytoplasmic cysts. B and C, pathognomonic cells slightly out of focus.  $\times 2250$ .

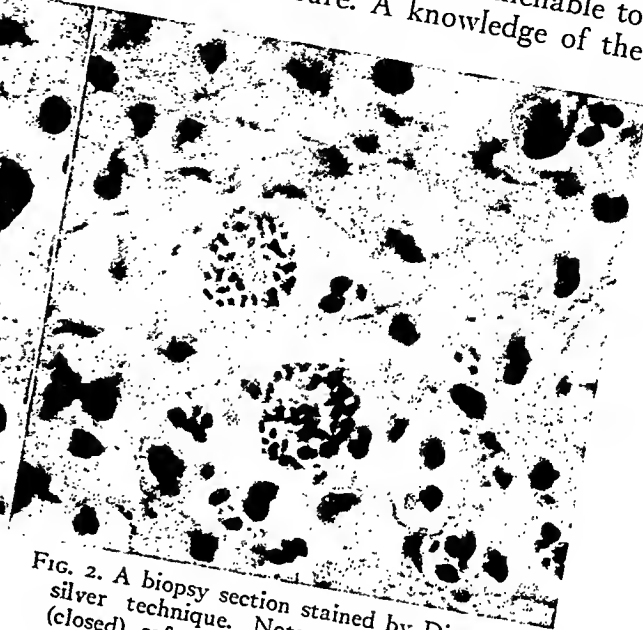


FIG. 2. A biopsy section stained by Dieterle's silver technique. Note the characteristic (closed) safety pin appearance of some of the so-called Donovan bodies filling the intracyclic spaces of the pathognomonic cells.  $\times 2250$ .

granuloma venereum to be made by histologic study of the tissue."

To this description the authors<sup>5</sup> have further added that: "The affinity of the intracyclic bodies for silver salts facilitates the recognition of the characteristic cell. With silver these bodies are stained black to brown and have a (closed) safety pin appearance because of their elongated ovoid and intense bipolar staining reaction." (Fig. 2.)

The rôle played by the lymphatics in this disease is at present under study. Histologic study of tissue removed from the inguinal pseudo-bubo reveals not a lymphadenitis, but a subcutaneous granulomatous reaction.

**Clinical Manifestations.** In the past the literature and textbooks have pictured this disease as an extensive, destructive, incapacitating ulceration, foul to one's nostrils and loathsome of one's sight. An understanding of the early lesions will dispel such a notion. The recognition of its

vulvar, perineal, vaginal, cervical and inguinal types of lesions is therefore of primary importance. A typical early vulvar lesion is illustrated in Figure 3. The clean raised tuft of velvety red granulation tissue with well defined borders is characteristic. A small perineal lesion, slightly ulcerated in its central portion but with definite rolled edges, is demonstrated in Figure 4. The vaginal manifestation exhibiting the raised rolled margin is pictured in Figure 5. The purely cervical nature of this disease, which has been only recently established<sup>6</sup> as belonging to this group, is reproduced in Figure 6 from a drawing of a characteristic case. Figure 7 illustrates an inguinal subcutaneous granuloma (pseudo-bubo) shortly after ulceration. Before ulcerating it appeared as an indurated mass which clinically did not differ greatly from the bubo of lymphogranuloma venereum or that of chancroid.

The early lesion, if it remains undiagnosed or if treatment is delayed, may spread to involve the whole pudendal re-

gion. The lesions soon become secondarily infected with spirochetes, fusospirochetes and/or other organisms. The ulcerations

*Complications.* Syphilis, or evidence suggestive of syphilis to the extent of a positive serologic test, is the most common



FIG. 3. Early vulvar granuloma inguinale (venereum).



FIG. 4. Early granuloma inguinale (venereum) of perineum.

then become extensive, deep, destructive and foul. Figures 8 and 9 illustrate such a case.

In addition to the above manifestations, granuloma inguinale (venereum) has been

complication. Important as it is to treat the syphilis, it has proved a bugbear in masking the true diagnosis. Another common complication altering the nature of the disease and adding to its virulence and



FIG. 5.—Early vaginal granuloma inguinale (venereum).

found extragenitally (upper lip in one case<sup>6</sup> and neck in another<sup>11</sup>). In one case reported by Pund and Gotcher<sup>7</sup> the body of the uterus, the tubes and ovaries were extensively involved.

chronicity is secondary infection with fusospirochetes. (Fig. 10.) Coincident lymphogranuloma venereum in its various forms, such as elephantiasis vulvae or rectal stricture, as well as chancroid ulceration or

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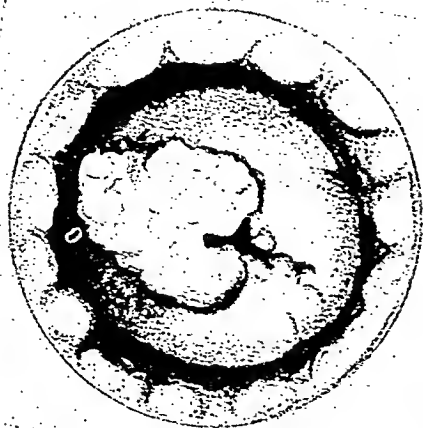


FIG. 6. Cervical granuloma inguinale (venereum).  
(Photograph from a drawing by Dr. E. A. Wilcox, University of Georgia School of Medicine.)



FIG. 7. Pseudo-bubo of granuloma inguinale (venereum).



FIGS. 8 and 9. Advanced granuloma inguinale (venereum).

gonorrhea, may be present. In fact all five of the venereal diseases have been observed in one and the same patient.

unhealthy appearance with ropy puriform discharge. It must be differentiated from all other causes of chronic granulomatous



FIG. 10. Photograph of a camera lucida drawing  $\times 2000$  of Donovan bodies within histiocyte. With Wright-Giemsa stain, capsules of the bodies are pink, metachromatic bars or nuclei are blue-black. Note superimposed fusospirochetal infection to which usually insufficient attention is given. (From Greenblatt et al., in *J. M. A. Georgia*, 26: 16, 1937.)

**Diagnosis.** It is to be borne in mind that granuloma inguinale (venereum) is a chronic infection usually limited to the skin and subcutaneous tissues and not primarily of the lymphatics. However, it has been found in the vagina and on the cervix. The affection is characterized by a chronic ulcerative, destructive granulation tissue that commences from a small macule somewhere in the pudendal region. It grows by continuity and may spread from the groin or perineum to the abdomen and thighs. Early the granulations are pink to red in color and are raised and clean in appearance. At this stage the granulations bleed readily on mechanical irritation. After secondary infection sets in, it may be covered by yellowish crusts and takes on an

ulceration, especially lymphogranuloma venereum, chronic chancroid and fusospirochetosis, as well as secondary forms of syphilis, carcinoma and tuberculosis.

The clinical diagnosis of granuloma inguinale (venereum) must be corroborated by the demonstration of Donovan bodies in smear or in tissue section. A positive diagnosis should be made only when these bodies are found.

While the uncomplicated disease is fairly uniform in its manifestations, the incidence of associated secondary contaminants is so high that the clinical picture is frequently altered. A successful way fully to diagnose each case is to carry out the following routine, much of which is laboratory in nature: (1) repeated Wassermann or Kahn

tests to rule out syphilis; nigrosine stain<sup>8</sup> or dark field study for treponema pallidum and other spirochetes; (2) smears stained for gonococci, Donovan bodies, fusospirochetes, Ducrey bacilli, yeasts, etc.; (3) chancroid intradermal tests;<sup>9</sup> (4) Frei test; (5) biopsy for Donovan bodies in tissue section, since not infrequently it is difficult to demonstrate these bodies in smears because of marked contamination by other organisms. The biopsy will establish the diagnosis in such cases and at the same time rule out tuberculosis, carcinoma, etc. To facilitate the diagnosis, all buboes, including the pseudo-bubo of this condition, should be aspirated under sterile conditions and routine smears and cultures made.

**Therapy.** I. The complete diagnosis with the complications is the first requisite. II. Treat syphilis, gonorrhea or chancroid, if present, coördinately. III. Treat fusospirochetosis or other invaders when present. These are often the cause of much discomfort and great damage to tissues. Specific therapy of granuloma inguinale (venereum) has little effect unless these secondary invaders are checked. We have found 4.5 per cent neoparsphenamine in equal parts of glycerine and cod liver oil excellent as a local application to check the phagedenic effect of the saprophitic fusospirochetes, to serve as a prophylactic against such contaminants and to promote healthy granulations and healing.<sup>10</sup> This mixture will prove more tolerable if some local analgesic such as nupercaine is added. Perborate, peroxide or potassium permanganate washes are valuable.

IV. Specific treatment with fuadin intramuscularly or 1 per cent tartar emetic intravenously is of definite value, notably in the early cases. This therapy must be continued over a long period of time even after apparent cure. If this is not done recurrences are inevitable. The value of this medication as a therapeutic agent decreases in direct ratio with the chronicity and duration of the disease. Therefore, early diagnosis of the lesion is of the greatest importance.

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# TENDON INJURIES

## THEIR CLASSIFICATION AND EARLY TREATMENT

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*Introduction.* Of all the injuries to the hand—that incomparable tool of the human machine—injuries to the tendons and nerves, and infections of the tendon sheaths, are often the most difficult to manage, the most protracted in their convalescence, and the most likely to leave a permanent disability. A derivative of connective tissue, tendon has inherited in a measure its ancestral capacity for regeneration, but has lost its hardihood towards infection to such an extent that it is safe to assume that any tendon that lies completely bathed in pus for more than forty-eight hours may lose its viability and slough out. Exposed to vulnerability in the fingers and hand, and susceptible of infection with possible permanent damage and deformity, tendons, when injured, become a major surgical problem economically, psychologically, and sociologically.

*Classification.* In considering tendon injuries, one is impressed by the close similarity in the mechanism operating in producing these traumapathies to that of bone injuries, and their treatment may well be approached along the same lines as in the case of fractures. Thus considered, tendon injuries fall into two types: (1) simple, without any break in the skin; and (2) compound, in which the laceration in the tendon follows a break in the skin and underlying tissues, exposing it to contamination. Either may be complete or incomplete; retracted (displaced) or not retracted; single or multiple; comminuted (frayed) or non-comminuted.

Type 1 is often the result of an injury from a blunt instrument, as at the knuckles where the taut tendon is caught between the traumatizing agent and the bone, and

breaks or tears. It may also follow muscular violence, as in a rupture of the quadriceps extensor tendon, plantaris tendon, or the extensor tendons of the fingers from their insertion, etc.

Type 2 follows an injury from a sharp penetrating instrument, such as a knife, glass, scissors, etc.

Viewed in this light, we approach the treatment of lacerated tendons, which are compounded, in the same manner as we do compound fractures. Appreciating that the time interval for the application of treatment is an important element in the ultimate successful outcome, we treat these cases as an emergency, knowing that the earlier the reduction, the easier and better it will be. The retracted ends of the tendon are more readily coapted without any difficulty. Experience teaches us that here, as in all wounds of compounding, there is a golden period which lies within the first six hours of the injury, during which time the wound is contaminated but not infected, and any operative procedure accomplished within this time is more likely to result in primary union and obviate the possibility of secondary infection. Also, whenever infection has already set in, it is best to treat it first, resorting to secondary repair or a plastic reconstruction of the tendons six months to one year later when we are reasonably sure that a latent infection will not be stirred up by operative intervention.

We appreciate that lacerated tendons without a break in the continuity of the skin may be difficult to diagnose, attention more often being centered upon the effects of the contusion of the surrounding soft and hard tissues. The true lesion is not dis-



covered until later, when persisting impaired function indicates the possibility of a tendon injury. It is noteworthy that here again the analogy to a fracture can be further considered, in that sometimes we have an unrecognizable linear fracture in which the attention is drawn to the contusion of the soft parts, the fracture being revealed only by a routine x-ray check-up.

Healing in tendon injuries also exhibits a close similarity to that of bone, in that both show early callus formation, to be followed later by replacement of tendon and bone tissue, respectively. The paucity of contact tissue functioning in the repair of tendon—the cross section of which is but a small fraction of its entire length—don in the action of the muscle, bear another similarity to bone, where the cross section of the healing fracture site is but a small part of the entire length of the bone, yet the weight-bearing and supportive stress placed upon it may be very great.

**Repair.** The scanty vascular supply of tendon in general, and sheathed tendons in particular, and the necessity of a good vascular supply for repair, are two factors which appear to be constantly working against the surgeon. The clinical observation that unsheathed tendons which receive a liberal vascular supply from surrounding areolar tissues are more resistant to infection and heal better and more quickly than their sheathed kindred, is amply demonstrated in the rapidity and persistent regularity with which the severed tendo Achillis heals, even in the presence of a decided gaping.

The normal function of the tendon sheath is to act as a fluid buffer where tendon rubs against bone or ligament (Mayer<sup>1</sup>). This is particularly true whenever a tendon, at some phase of its motion, is forced to turn a corner. The rôle of the tendon sheath in repair of a severed tendon is to establish early continuity within a few days. Mason and Shearon<sup>2</sup> have shown that after the fourth or fifth day the tendon itself begins to proliferate and to

send cells into the callus, and if the gap is not too big it may be bridged by tendon cells within about two weeks. After the sheath has served its purpose of splinting the early union, it begins to become more lax and areolar and, in a successful suture, to take on again its original function of serving as gliding tissue. This process of healing also takes place in autogenous tendon grafts, as well as sutured tendons. The force of these facts is more strongly brought out when it is remembered that adequate vascularization of grafted tissues, e.g., skin or bone graft, require rest and immobilization necessary to obtain an efficient vascular bed to secure union, while rest and immobilization of injured tendons or in tendon grafts favor the formation of adhesions—the most important single factor making for the functional failure of operation on tendons. Experimental and clinical observations have shown that function is of major importance in determining the histologic structure of tendon tissues and emphasizes the necessity for purposeful movement of tendons during the course of healing.

The tension at which tendons should be sutured is a very difficult and perplexing problem. While there is no doubt that freshly severed tendons should be sutured end-to-end, after relaxation has been obtained by bringing the origin and insertion of the muscle as close together as possible, the problem is not so simple when one considers suture and repair of old injuries. Here the retraction is due not only to muscular tonus, but to intramuscular fibrosis as well, and while the former may be overcome, the latter is, to a certain extent, permanent, and end-to-end suture leads to permanent shortening of the tendon. This necessitates some form of plastic tendon lengthening to overcome the post-fibrotic shortening.

**Pathology.** The fundamental pathology occurring in tendon injuries follows a single local damage to the skin. But there is a wide diversity of involvement of the underlying structure so that often a

seemingly harmless laceration of the skin may reveal, upon exploration, a multiplicity of severed tendons, nerves, and

ically, this level shows a high incidence of tendon injuries. Unfortunately, the surface of the tendon most exposed to friction and

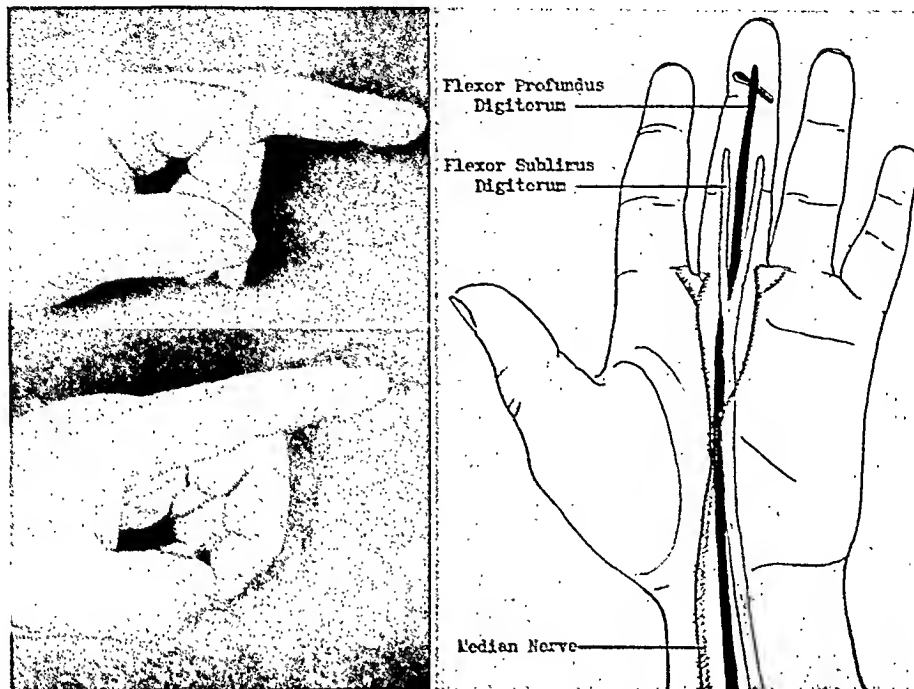


FIG. 1. Laceration across flexion crease of distal interphalangeal joint of middle finger, left hand. Operative repair. Result ten weeks after operation showing lateral prolongation of operative incision in search for proximal end of tendon.

blood vessels. These injuries are not alone localized to the site of injury but extend above and below its level, depending upon the state of tonus or tension of the individual tendons and their corresponding muscles at the time of the injury, and the movements and position of the hand at the time of the impact. This becomes especially apparent in injuries on the flexor surface of the wrist. There the flexors of the fingers and the nerves to the hand and fingers form the greatest single convergence in the body of a number of important tendons and nerves, all of which are exposed to vulnerability by a single stab or cut. The crowding of all these important structures into a small space makes for a great tendency to agglutination by adhesions following injury.

The wrist region, both flexor and extensor, because it has traversing about it all the tendons (twenty-six) and nerves to the hand and fingers, becomes the most vulnerable site for tendon damage. Clin-

ically, the one most prone to adhesions—the anterior surface—receives the greatest effect of the impact in complete severance and is the one injured when partial injury of the tendon occurs.

Similarly, a large tendon callus follows laceration of the extensor tendons over the knuckles, appearing on the superficial or exposed surfaces of these tendons. Retraction is greater in flexor tendons than in extensor tendons, with the exception of extensors to the thumb where the proximal ends are often difficult to find because of a rapid and extensive retraction, sometimes as much as two-thirds up the forearm. The extensor tendons of the fingers, because of the lateral expansions, remain more fixed when severed, and do not retract as much as the flexor tendons.

The writer has found that the nearer the injury of the tendon to its insertion, the greater the retraction, so that the greatest retraction is found in lacerations of the flexor tendons in the fingers (espe-

cially the little finger) and palm of the hand, and lacerations of extensor tendons to the thumb at its base. However, the out operative intervention by maintaining the finger in hyperextension by means of some adequate splintage.

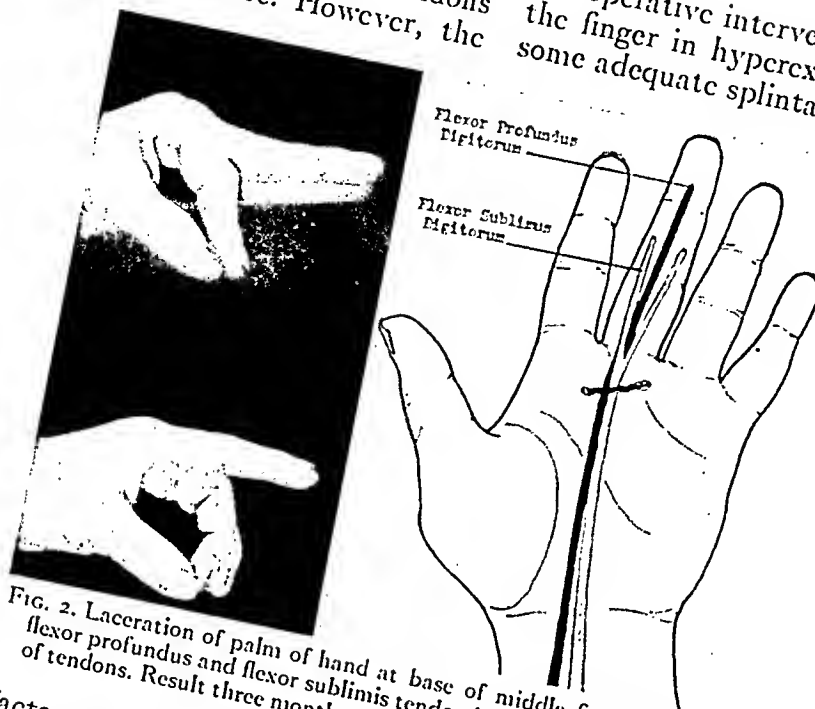


FIG. 2. Laceration of palm of hand at base of middle finger involving flexor profundus and flexor sublimis tendon before bifurcation. Suture of tendons. Result three months after operation.

greatest single factor responsible for retraction following severance of a tendon is the time interval elapsing from the injury to surgical intervention. Where retraction is already established, finding the tendon may be done by milking the proximal end of the tendon distalward, following relaxation of the involved muscles, or by catheterizing the sheath with a probe until the proximal end is felt, the tendon located, transfixed, and threaded through its sheath toward the operating field.

**Treatment.** As stated, treatment in tendon lacerations is based on the type of injury present. In Type 1 injuries, where there is a laceration or rupture of tendons without break in the skin, we are dealing with a clean injury without contamination, and any exposure of the tendons is made with surgical intent under aseptic conditions predisposing to uniform primary healing. It is possible, in selected cases of this type such as avulsions of the extensor tendons of the fingers from their insertion or laceration of these tendons near their insertion, sometimes to effect repair with-

We agree with Mason<sup>3</sup> that healing is more apt to take place in avulsed extensor tendons, when there is a flake cortical fracture of the phalanx associated with the avulsion by maintaining the finger in slight hyperextension for about six weeks. The regenerative power of the extensor tendons is such that if given a chance by good approximation, healing will take place. It must be borne in mind, however, that under these conditions healing may occur with the tendon in a lengthened condition with subsequent dropped finger tip. Also, in most tendon injuries occurring near the insertion of the extensor tendons, the joint space of the distal interphalangeal joint is opened, allowing loose tabs of tissue to lie within the joint, predisposing to ankylosis in partial flexion. Because of these possibilities, operative repair becomes the procedure of choice. If the joint space is cleaned out of loose or attached tabs of tissue, the capsule and tendon carefully repaired with fine silk, hyperextension maintained for three weeks, and no infection incurred, the results are

usually good. All other subcutaneous tears or lacerations of tendons automatically fall into the operative group.

dressings. The patient is requested systematically to flex each phalanx of the individual fingers, beginning with the

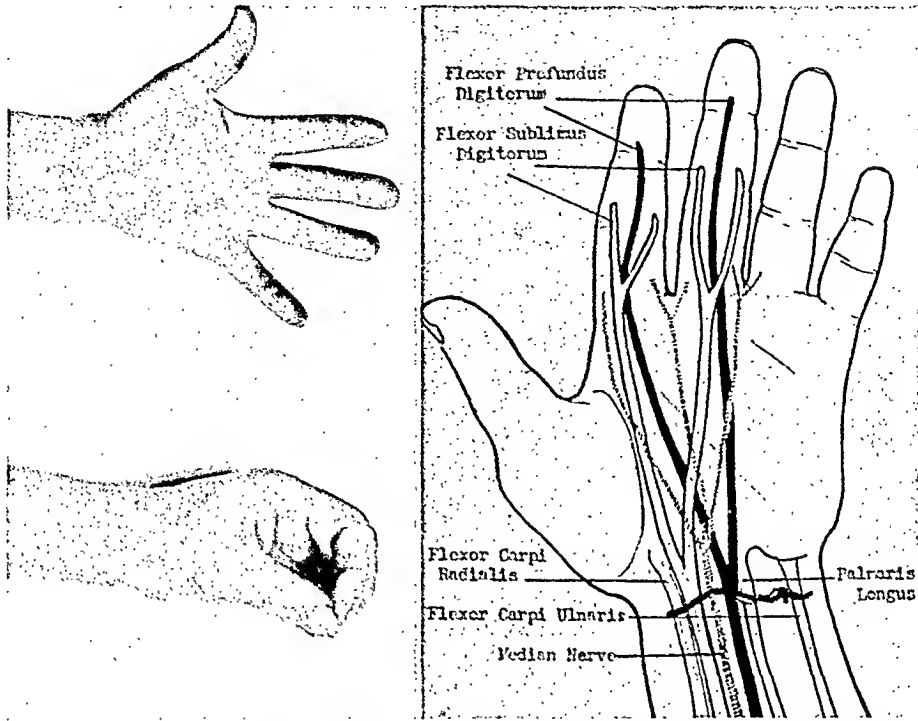


FIG. 3. Laceration across left wrist involving palmaris longus, flexor carpi radialis, flexor sublimis and profundus digitorum to index and middle fingers, flexor carpi ulnaris and median nerve. Immediate exploration and suture of tendons and nerve. Result five months after operation.

Type 2 injuries—or compound lacerations of tendons—are acute operative surgical emergencies, and are dealt with in the same manner as compound fractures. This implies an immediate sterilization of the wound, control of hemorrhage, and application of a sterile dressing. This is followed by temporary splintage of the part for complete relaxation of the origin and insertion of the tendons to minimize the amount of retraction that will take place until operative intervention. Hemorrhage, if present, has in our experience proved to be an excellent internal lavage of the wound, and it is the writer's observation that compound lacerations of the tendons in which a generous hemorrhage was present were more likely to heal without infection than lacerations of tendons in which the wound was bloodless, dry and anemic.

At this time the wound is looked at, but not into, and covered with a sterile

thumb, to determine the amount of tendon damage present, and whether tendons are partially or completely severed. Further, the integrity of the nerves to the parts is tested, by requesting the patient to use the intrinsic muscles of the hand, i.e., abduction and adduction of the fingers, and adduction of the thumb for the ulnar and apposition of the thumb for the median. The sensory involvement is also determined, giving a definite picture of the character and extent of the damage present and, to some degree, an index of the enormity of the operative problem.

As the operative procedure may be time consuming—especially where there is a multiplicity of tendons involved with crushing and contusion of lacerated tendon stumps—the type of anesthesia becomes important. General anesthesia is the one of choice. Local block anesthesia at the elbow is desirable wherever possible, as it allows the surgeon to gauge the tension

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at which the tendons are to be sutured. This is particularly true in loss of tendon substance. Local infiltration at the site of

of the outcome in tendon repair, namely, infection. Next, all dead and devitalized tissues

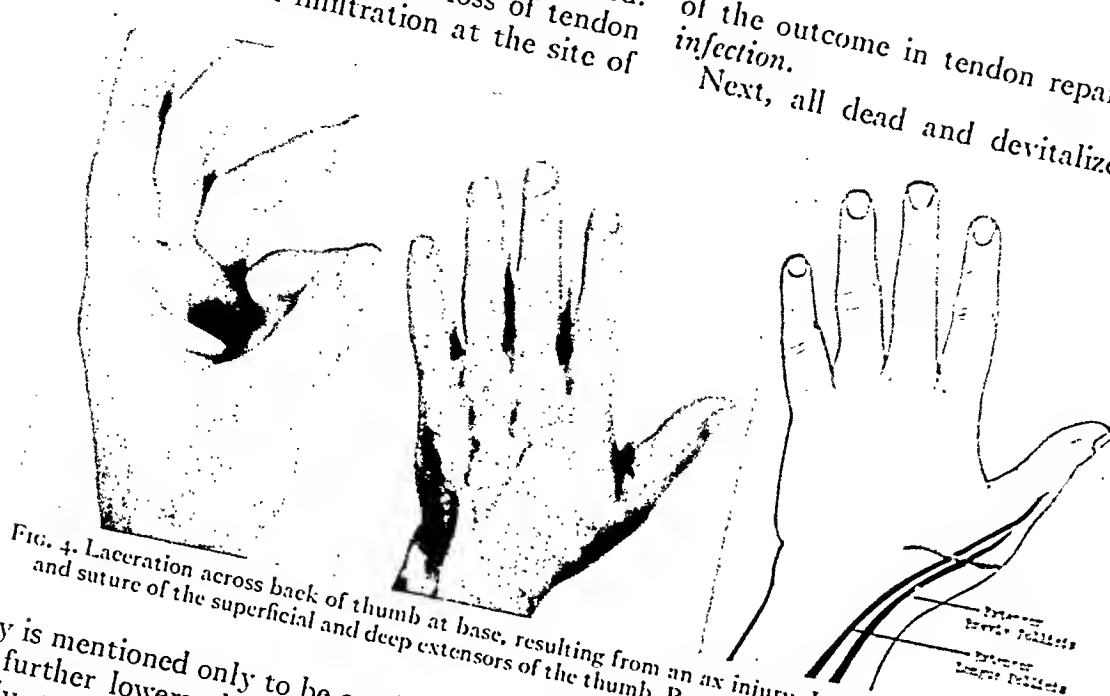


FIG. 4. Laceration across back of thumb at base, resulting from an ax injury. Immediate débridement and suture of the superficial and deep extensors of the thumb. Result fourteen weeks after injury.

injury is mentioned only to be condemned, as it further lowers the resistance of the already traumatized tissues and invites infection.

Operative repair demands accurate end-to-end apposition of tendon stumps, using fine silk as the suture medium and the atraumatic lacing technique described by Bunnell.<sup>4</sup> This, however, should always follow a preliminary preparation of the skin and wound, by thorough scrubbing of the skin with soap and water. The wound is protected by a sterile sponge to prevent washing further contamination into it. The wound is then irrigated with copious amounts of sterile saline, thereby floating to the surface all debris, blood clots, or any foreign material that may have been introduced at the time of injury. The parts are dried, the skin painted with tincture of iodine, and the wound generously swabbed with the iodine. This is followed by instillation of half strength tincture of iodine into the wound itself. The iodine should reach every nook and cranny of the contaminated wound. This is essential to obviate the most important single complication that interferes with the success

from the surface to the depth of the wound are carefully excised, all structures being handled gently and carefully. One must avoid crushing tendons. Where necessary the frayed ends should be freshly cut to obtain good approximating surfaces. If it becomes necessary to extend the original wound for an adequate exposure in the operating field, it is important to remember to avoid cutting across the normal flexion creases in the digits, and, wherever possible, to refrain from cutting on the anterior surfaces of the fingers.

Searching for the retracted proximal ends of the flexor tendons in the fingers should be done by progressive incisions on the lateral surfaces, avoiding the flexion creases. When located, the end is transfixed with a silk suture, and with the finger and hand in flexion, the retracted end is gently threaded through the sheath and drawn into the operative field. As each proximal end of the tendon is located, transfixing it with a silk suture helps to identify it and minimizes the trauma produced by grasping and holding it with a clamp.

Where a loss of substance is present, the simplest and easiest type of tendon plastic

should be done for the restoration of length, avoiding the use of free tendon grafts in freshly divided tendons. Where a simple type of tendon plastic is not expedient, it is better to defer extensive tendon operation for a later reconstruction when the possibility of infection from a contaminating wound has passed. The deep flexor should always be saved when both superficial and deep flexors are involved, as it is the more powerful and more important of the two tendons. Repairing both at the same time tends to form adhesions between them, and between the tendons and the surrounding soft parts, unless provisions are made to prevent this. In loss of substance of both flexor tendons, the adjacent normal flexor sublimis may be transplanted and made to assume the role of main flexor for the involved finger.

Fine black suture is the one of choice in repairing freshly divided tendons because it can be easily handled without tearing through the tendon substance, produces the least absorptive reaction in the tissues, and allows early motion. It is important to use a straight non-cutting edge needle in order not to cut the tissues nor the suture when doubling up in the Bunnell<sup>5</sup> stitch. The knot is buried between the approximated surfaces.

Repair of the tendon sheath is an essential step because it protects the tendon suture line, prevents adhesions, and functions in the early stages of tendon repair. This is effected by using a continuous fine plain catgut suture. Where the tendon sheath is irreparably damaged, every effort should be made to reconstruct it, using a segment of vein (if necessary). The repaired tendon may be covered with fat, fascia, or areolar tissue before suturing the skin to prevent the formation of adhesions. The skin should be carefully approximated to insure primary union. It is important, when sewing the skin of the palm, to evert it so that it does not pucker in, causing adhesions between it and the palmar fascia. The use of a tourniquet is an advantage in

operative tendon work, and the blood pressure machine cuff makes an excellent pneumatic tourniquet.

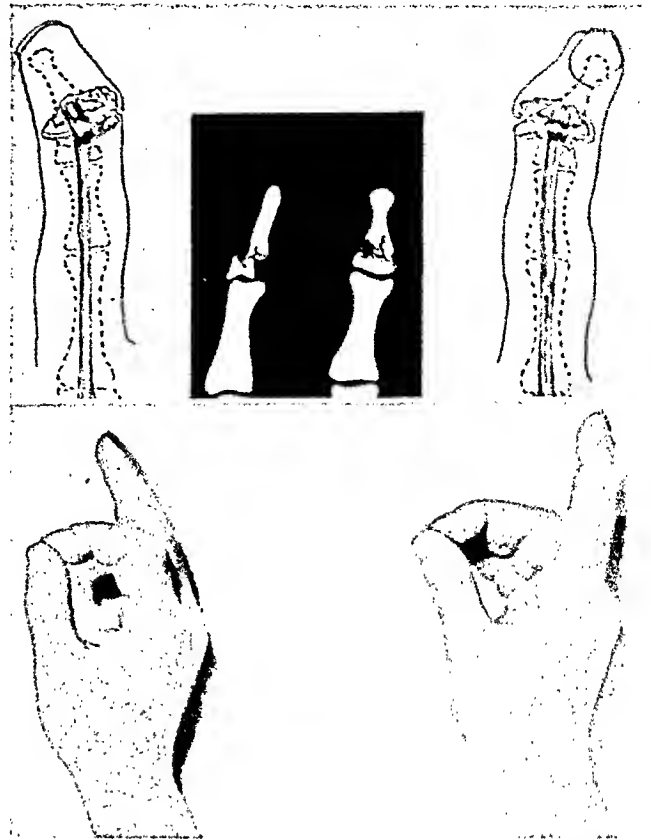


FIG. 5. Crushing injury of distal end of right index finger, with almost complete amputation of tip resulting in a complete laceration of the extensor tendon. Débridement, replacement of tip, and suture of skin only, and immobilization in neutral position without suture of tendons. Tendons were not sutured because at the time of operation it was felt that the small tab of skin bridging the tip to the rest of the finger might not be sufficient to maintain its circulation, but the tip remained viable and the tendons healed spontaneously. Functional result two months after operation.

When drainage is used, it should consist of a fine strand of twisted silkworm gut, with the drain placed to the tendon sheath and not within it, that is, drainage is for the skin and subcutaneous areas. Maintenance of relaxation at the operative site to relieve tension on the repaired parts is effected by immobilizing the fingers and hand in a moulded plaster of Paris splint. Where there is a history of soil contamination attending the injury, a prophylactic injection of tetanus and gas bacillus antitoxin is given routinely.

**Postoperative Treatment.** Supervised gentle and purposeful early active movements of the fingers are begun within forty-eight hours after the operation, while the muscles are relaxed in splintage. The movements should be done under the direction of the surgeon, and are carried out by having the patient move both hands simultaneously. Cautious but complete excursions in flexion and extension of the fingers are carried through several phases and repeated twice a day. We find that by coördinated action of both hands in unison, the act, being purposeful, becomes easier. In this we agree with Harmer<sup>6</sup> who advocates early supervised motion following repair of tendons without neural involvement. No force is exerted upon the tendons before the third week, and when instituted, it is done slowly and carefully.

This early motion has a dual effect—it prevents agglutination between tendon and tendon sheaths, obviating the formation of later adhesions, and the tension exerted upon the suture line stimulates the early formation of a callus weld. It also tends to lessen the period of splintage, maintaining muscle tonus, and restoring early function. The average period of splintage in this series of cases was ten days.

**Postoperative Infection.** The incidence of early postoperative infection has become a relatively rare occurrence, as the result of gentle but thorough cleansing and débridement of the wound before repair is instituted. There are instances, however, where infection and breakdown of the operative wound occurs in spite of every precaution. This occurred three times after operations within the "golden period," twice in cases of blows of the closed fist against human teeth with laceration of the extensor tendons and compound fractures of the proximal phalanges; one instance followed cleavage of tendon and phalanges from an axe injury. It is noteworthy that all these cases of early postoperative infection were associated with compound fractures.

There are also instances where delayed breakdown may take place weeks or months after a tenorrhaphy with primary healing. This is manifested by redness, tenderness, and the formation of one or multiple blebs along the operative scar. Incision often reveals each bleb as consisting of a pus blister within which the suture material lies freely exposed. When this occurs, it is necessary to remove the entire offending suture before complete closure will take place. There were four cases of delayed breakdown—two at the wrist, one in a digit, and one in the tendo Achillis. At first, we were inclined to blame the suture material alone for these sequelae, but investigation demonstrated that in some individuals in whom the breakdown of the wound took place, a distant pyogenic focus of infection was present elsewhere in the body and the secondary breakdown at the tendon suture line was most likely disseminated by a hematogenous route.

On the other hand, there were cases where the suture material was extruded through the skin without any evidence of infection present. Some of these sutures were sloughed out as late as three years postoperative. The patient would state that a "black speck" could be seen at first beneath the skin at the suture line. This worked its way through the skin and the "threads hung out." This working of the suture material to the surface is more likely to occur in the fingers, where there is a paucity of tissue intervening between the suture line and the skin, and the constant friction of movement in these parts propels the foreign material to the skin surface and out. This happened six times, and each time it followed suture of tendons in the digits.

#### ANALYSIS OF CASES

This report is based on ninety consecutive unselected cases of tendon injuries, representative of the common sites in the body where accidental division of tendons occurs. It is, therefore, not limited to injuries in tendons of the hand alone.



These cases are from the Department of Traumatic Surgery, of the New York Post-Graduate Hospital and the Reconstruction Hospital (Dr. John J. Moorhead, Director). They represent personal cases and cases from the services of Dr. Henry H. Ritter and Dr. Herbert Bergamini.

In the group of ninety cases of tendon lacerations reported here, seventy-five were of Type 2 (compound) and fifteen were of Type 1 (not compounded).

The distribution, as to parts involved, was as follows:

	No.			
Hands and fingers.....	78	{ Males	Left.....	30
			Right....	37
		{ Females	Left.....	5
			Right....	6
Tendo Achillis.....	3	{ Males	Left.....	1
			Right....	1
		{ Females	Left.....	0
			Right....	1
Quadriceps extensor.....	6	Males	Left.....	2
		6	Right....	4
Patellar tendons.....	2	Males	Left.....	0
		2	Right....	2
Biceps tendons.....	1	Males	Left.....	0
		1	Right....	1

The total number of males who suffered tendon injuries is seventy-eight, females, twelve. Included with this list were eight children.

*Age Incidence.* The oldest patient in this group was 76 years of age; the youngest, 2 years. The average age was 28 years.

*Causes of Lacerations.* Lacerations resulting from sharp instruments were as follows:

Glass	{ 61 cases	{ Hands and fingers.....	58
Knife			
Axe		{ Tendo Achillis.....	3
Metal			
Porcelain, etc.			

Lacerations resulting from blunt instruments:

Lead pipe	{ 14 cases	{ Hands and fingers....	14
Iron pipe			
Door			
Auto			
Rock			
Window ledge, etc.			

Lacerations resulting from muscular violence:

15 cases	{	Patellar.....	2
		Biceps.....	1
		Fingers—Extensors.....	6
		Quadriceps—Extensors.....	6

*Time Interval from Injury to Surgical Intervention.* Forty-five patients were operated on within six hours of injury. In the remainder the time interval was as follows:

24 hours.....	10
3 days.....	8
1 week.....	7
2 weeks.....	4
4 weeks and over.....	7

Of the eighteen cases in which the delay was one week or more, seven were Type 1 avulsions of the extensor tendons of the fingers from their insertion without break in the skin; five were lacerations of the flexor tendon at the wrist that were overlooked in suturing a seemingly superficial laceration of the skin, and came to secondary operative repair from one to four weeks after injury; three were overlooked flexor tendons in laceration of the palm, operated on within ten days; three were quadriceps extensor tendons.

The end results following tendon lacerations when treatment is carried out systematically under guided supervision often gives a complete restoration of function, and the period within which this is accomplished is measured, not in terms of days or weeks, but rather in that of the intelligence and coöperation of the patient to execute these early movements.

In arriving at the functional end results in tendon injuries, the numerical ratio and mathematical grading adopted by Moorhead<sup>6</sup> for fractures was used: 60 per cent for function, and 20 per cent for union and contour. Function, or the capacity to perform, is measured in terms of the ability fully to flex or extend the part, as the case may be. Union, or the state of repair, is measured by the character and extent of the tendon callus which may be sufficient, exuberant, or attenuated, lengthening the



SITES OF LACERATIONS IN HAND

	No. of Cases	Flexors			Extensors		
		Total	Left	Right	Total	Left	Right
Thumb.....	9	6					
Index.....	20	7	1	5	3	3	0
Middle.....	13	3	5	2	13	3	10
Ring.....	2	1	1	2	10	4	6
Little.....	5	0	1	0	1	1	0
Wrist.....	23	13	6	7	5	3	2
Hand.....	5	1	0	1	10	5	5
Forearm.....	1	0	0	0	4	3	1
	78	31	14	17	47	22	25

NUMBER OF TENDONS INVOLVED

No. of Tendons Involved	No. of Cases	Flexor			Extensor		
		Total	Left	Right	Total	Left	Right
1	35	10					
2	21	13	3	7	25	10	15
3	12	1	0	6	8	4	4
4	7	1	0	1	11	0	11
5	2	4	1	1	3	1	2
10	1	1	0	2	0	0	0
	78	31	11	20	47	15	32

Total number of tendons sutured in 90 cases... 173  
 Hand, wrist and fingers..... 161  
 Others..... 12

SITES OF LACERATIONS IN DIGITS\*

	Total	Joint	Flexor			Extensor		
			Total	Left	Right	Total	Left	Right
Thumb.....	9	A B C	4 2 0	1 0 0	3 2 0	3 0 0	3 0 0	0 0 0
Index.....	20	A B C	3 4 0	1 4 0	2 0 0	4 5 2	2 2 5	2 2 0
Middle.....	13	A B C	1 2 0	0 1 0	1 1 0	4 4 2	1 1 0	3 3 2
Ring.....	2	A B C	1 0 0	1 0 0	0 0 0	1 0 0	1 0 0	0 0 0
Little.....	5	A B C	0 0 0	0 0 0	3 2 0	1 2 0	2 0 0	0 0 0
	49	..	17	8	9	32	13	19

Total of Injuries at "A" Joint—Flexor..... 9  
 Extensor..... 15

Total of Injuries at "B" Joint—Flexor..... 8  
 Extensor..... 10

Total of Injuries at "C" Joint—Flexor..... 0  
 Extensor..... 7

\* The metacarpal phalangeal, proximal and distal interphalangeal joints are designated here as "A," "B," and "C" joints, respectively.

tendon. Contour is measured in terms of deformity, swelling due to excessive tendon callus, and appearance of operative scar or scars.

End results were obtained in eighteen cases in this series. These included four cases of laceration at the flexor surface of the wrist, in two of which the median nerve was involved; three cases of lacerations of the flexor tendons in the palm; two cases of lacerations of both superficial and deep flexors in the digits, three cases

of lacerations of the long and short extensors of the thumb; two cases of avulsion of the extensor tendons of the fingers from their insertion; and two cases of lacerations of the tendo Achillis. In this group, two were Type 1 and sixteen were Type 2; fifteen were males and three were females.

No case was evaluated for end result earlier than three months, this being regarded sufficient time for complete restoration of tendon function. The average grading for all the follow-up cases was 85 per cent, divided into 50 per cent for function, 17 per cent for union, and 18 per cent for contour.

## CONCLUSIONS

1. Division of tendon injuries into Type 1 (simple, without a break in the skin) and Type 2 (compound), places these injuries in the same standardized classification as skeletal injuries, of which they are a complement.

2. This practical classification automatically divides the Type 1 group into the "wait and see" class, and Type 2, into the "look and see" class.

3. Judged by this group of cases, no age is spared. Sharp instruments lead in the causation. No tissue is respected; cutaneous, neural, vascular, and bony tissues may share in the damage by the impact that severs the tendons. Any superficial injury, no matter how seemingly trivial, which reflects a suspicion of deeper struc-

ture involvement, should be investigated surgically for possible damage to underlying tissues.

4. This series of cases confirms the greater relative incidence of tendon injuries in the male, the proportion being about six to one; the greater incidence of Type 2 injuries; the more frequent involvement of the right extremity; the more frequent affection of the dorsal surface;

and long extensor of the thumb lead in frequency, in the order given, among the extensor tendons.

6. In freshly compound lacerated tendons, the time of repair (six hours) and thorough debridement are far more important than the character of suture material and the type of repair.

7. Early debridement and repair diminish the incidence of postoperative infection,

#### TENDONS INVOLVED IN HAND

	Total	Compound				Not Compounded			
		Complete		Incomplete		Complete		Incomplete	
		Left	Right	Left	Right	Left	Right	Left	Right
Flexor palmaris longus.....	11	4	7	0	0	0	0	0	0
sublimis digitorum.....	15	8	7	0	0	0	0	0	0
profundis.....	14	7	7	0	0	0	0	0	0
carpi radialis.....	6	2	4	0	0	0	0	0	0
carpi ulnaris.....	3	1	2	0	0	0	0	0	0
pollicis longus.....	6	2	3	0	1	0	0	0	0
pollicis brevis.....	2	1	1	0	0	0	0	0	0
	57	25	31	0	1	0	0	0	0
Extensor communis digitorum.....	16	3	11	0	0	0	2	0	0
pollicis longus.....	11	5	5	0	1	0	0	0	0
pollicis brevis.....	5	3	2	0	0	0	0	0	0
pollicis indieis.....	15	5	3	1	1	1	4	0	0
minimi digiti.....	11	3	7	1	0	0	0	0	0
	58	19	28	2	2	1	6	0	0

#### NERVE INJURIES

Total number of cases with nerve involvement.....	7
Median nerve.....	5
Ulnar nerve.....	2

In case both the median and the ulnar nerves were involved.

the wrist and fingers, particularly the index and middle fingers. The level of the "A" joint is the commonest site of tendon severance in the digits. In the lower extremities, the quadriceps extensor tendon, the tendo Achillis, and the patellar tendons lead, in the order mentioned.

5. Of the flexor tendons, the flexor sublimis, profundus digitorum and palmaris longus lead, in the order given, while the extensor communis digitorum, indices

but do not altogether eliminate delayed breakdown of the operative wound or later extrusion of the suture material without breakdown of the wound.

8. Fine black silk is the suture of selection, and the Bunnell stitch is the method of choice.

9. Early preliminary preoperative relaxation by splintage is important in facilitating and obtaining a good repair, while early regulated supervised post-

operative motion of the fingers (forty-eight hours postoperative) is essential in obtaining functional restoration of hand.

10. The index finger, thumb, and middle fingers are, the important digits. One must always try to save the outer side of the hand where the severity of this injury demands sacrificing parts of this important human tool. However, in the foot, one attempts to spare the inner side, this being the more important functional part of that member.

11. Patience is the keynote in treating tendon injuries: patience in evaluating the amount of damage present; patience in

repairing the damage wrought; and patience in restoring functionally what one has restored surgically.

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VARIATIONS in the degree of pain produced in inflammation depend on variations in the degree and location of the swelling. Thus, soft tissue inflammation is less painful than that developing in some rigid structure such as bone.

# VISCERAL COMPLICATIONS IN TUBERCULOSIS OF BONES AND JOINTS\*

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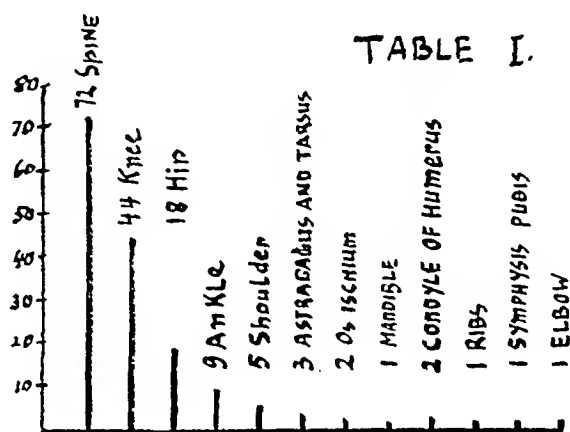
**T**UBERCULOSIS of the skeletal apparatus remains one of the most difficult problems in surgery, difficult because of the surgical technicalities involved and because of the chronicity of the lesion. Consequent to this chronicity is the ever present threat of visceral complication, a threat which, unfortunately, we are apt to await rather than to anticipate.

The present study is designed to investigate the nature of visceral involvement in tuberculosis of the bones and joints, and to determine to what extent it follows a predictable path. Is it possible to establish any rules enabling us to anticipate complications? At the outset of this investigation it was decided not to include cases presenting a terminal miliary dissemination since its pathway from the blood stream is rather diffuse and the sequence of visceral involvement speculative. Furthermore, it is not the intention of the author to enter into any discussion of theoretical concepts or to restate any of the physiologic or pathologic material easily available in current literature.

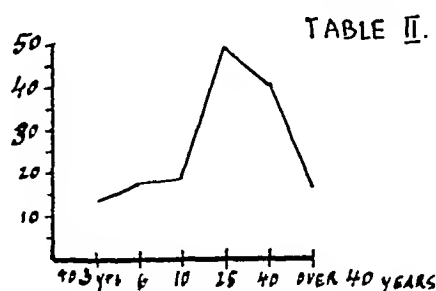
The material from which the present conclusions were derived consists of unselected cases of tuberculosis of bones and joints admitted to the Hospital for Joint Diseases and Mount Sinai Hospital for the five year period 1932-1936 inclusive. Out of a larger series, 159 cases were selected for study, these being all the cases definitely proved as tuberculous and presenting sufficient data to warrant interpretation.

Table I shows the distribution of the lesion in all 159 cases. Table II shows the distribution of the cases as to age, and Tables III and IV the distribution as to sex and age.

These data require no further discussion here since their pertinence to the present subject is incidental. Briefly, seventy-two cases involved the spine, thirty-five male and thirty-seven female; 44 cases involved



the knee, evenly divided between the sexes, and eighteen cases occurred in the hip joints, ten male and eight female.



Of these cases, ten showed evidence of visceral complications:

1. A 59 year old male had tuberculosis of the right hip and developed bilateral tuberculosis of the kidney.
2. A 39 year old male with tuberculosis of the spine developed perinephritic abscess.
3. A 40 year old female with tuberculosis of the spine developed Addison's disease.

\* From the Surgical Service, Hospital for Joint Diseases, and the Orthopedic Service, Mount Sinai Hospital, New York City.

JUNE, 1939

4. A 25 year old male with tuberculosis of the spine developed hydronephrosis. No tubercle bacilli found in urine.
5. A 26 year old male with tuberculosis of the spine developed epididymitis.
6. A 5 year old female with tuberculosis of the right knee developed tuberculous peritonitis.
7. A 3 year old male with tuberculosis of the spine developed left renal tuberculosis.
8. A 35 year old male with tuberculosis of the spine developed toxic hepatitis.
9. A 2 year old male with tuberculosis of the right mandibula developed left renal tuberculosis.
10. A 20 year old female with tuberculosis of the spine developed left renal tuberculosis.

renal tuberculosis and five tuberculous epididymitis. Harris, who systematically examined the urine of forty-three adults and sixty-seven children for tuberculous bacilluria, found tubercle bacilli in the urine in sixteen cases of the former and nine of the latter. Of his sixteen cases he reported five as certain tuberculosis of the kidney (31.6 per cent) and six as uncertain. He had no case of proved tuberculosis of the kidney in his juvenile cases.

TABLE IV (MALE).

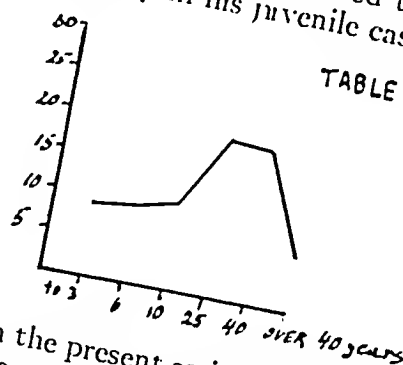
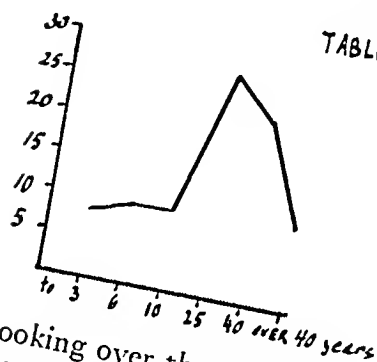


TABLE III (FEMALE).



Looking over these cases it immediately becomes apparent that most of the complications were secondary tuberculous infections, or possibly foci present without symptoms before the onset of perceptible bone and joint manifestations. Whichever it was, following or antedating the skeletal manifestations, insofar as the existing status was concerned, they presented a complication of the presenting lesion. Predominantly the complicating infection involved the genitourinary system (eight cases, 5 per cent). There were four cases (2.5 per cent) of proved renal tuberculosis and one case of proved epididymitis tuberculosa. These figures are higher than the findings of Duncan who reported genitourinary complications in 2.5 per cent. Snyder reported a still higher percentage. Of his 100 cases, eight were found to have

In the present series, the hydronephrosis of Case iv was caused by pressure of a cold abscess on the ureter. The kidney was shown not to be involved by tuberculosis. The occurrence of adrenal involvement in Case iii with the symptoms of Addison's disease is exceptionally interesting because of its rarity in the presence of other easily recognized gross tuberculous lesions. As for the hepatitis in Case viii, it is hard to say whether it was of tuberculous origin or not. The hepatitis cleared up completely after a few weeks.

The repeated demonstration of secondary genitourinary involvement in skeletal tuberculosis should suggest the advisability of examining the urine of all patients suffering from tuberculosis of bone and joints at regular intervals for tubercle bacilli, so that lesions might be discovered early. Since early renal tuberculosis gives no lead to the examiner because of lack of symptoms, repeated examination of the urine should be done as a routine. The appearance of tubercle bacilli may appear intermittently minimizes the significance of negative findings. Many progressive cases of kidney tuberculosis or tuberculosis of the ureter and bladder

could be thereby anticipated and proper measures instituted.

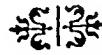
#### SUMMARY

1. One hundred fifty-nine cases of proved tuberculosis of bones and joints were examined, ten of which showed visceral complications.
2. Four cases of renal tuberculosis were found and one case of epididymitis.
3. All cases except one have secondary tuberculous lesions as complications.
4. The most frequent is the involvement of the genitourinary tract.

5. Routine examination of the urine for tubercle bacilli at repeated definite intervals should be included in the general supervision of cases of tuberculosis of the skeletal system.

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THE inflammatory reaction . . . is just as physiological as the healing process, since it is a response of nature which prepares the ground for the repair of lost, divided or dead tissue.

# A NEW CLOSED METHOD OF TREATING SUPRACONDYLAR FRACTURES OF THE ELBOW

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**S**UPRACONDYLAR fractures in infants and children are very common and generally present a distinct therapeutic problem. They are usually displaced and oftentimes comminuted with a great amount of accompanying soft tissue trauma. A careful thorough search should be made for any neural disturbance before reduction is attempted. Reduction should be done with the least amount of force, as gentleness in the entire manipulative procedure is of the utmost importance. Usually the acute flexion position can be counted upon to maintain the corrected osseous alignment, but this flexion is a very potent potential cause for Volkmann's ischemic paralysis. A too tightly applied bandage may within a few hours lead to unpleasant sequelae, but if it is loosened there is the likelihood of letting the fragments become somewhat displaced again.

Anterior and posterior moulded plaster of Paris splints and many other types of rigid immobilizing devices are being used and often are excellent. However, these appliances demand the elbow to be at not too acute flexion, and hence, at the start are at a disadvantage as a means of retaining the reduction. The pull of the triceps is ever present and must be counterbalanced by some mechanical method. Recently good results have been reported by the use of gravity pull with the wrist held by a sling and the elbow slung by this means in moderately acute flexion.

There are several surgical procedures for the treatment of this fracture, the simplest being the use of the Kirschner wire through the olecranon process with or without a plaster of Paris cast. There are many fractures about the elbow, which have to be operated upon with screw, nail or wire

internal fixation. There are also other cases which do very well with the use of tongs. Several other operative procedures are being used in the treatment of this injury.

The method, the description of which follows is, I believe, original, as I have not seen any mention of it in the literature. This procedure does not claim to be a panacea for supracondylar fractures, but is only to be used where it is applicable. However, in many cases it can be tried and if it does not prove successful other more drastic methods can still be undertaken. It has now been used on three patients with very good success; a short record of these is found below.

I have employed vinethene as an anesthetic in many dozens of infants with fractures and dislocations, and I find it excellent for the average case. A procedure lasting thirty minutes or thereabouts can usually be done very well under this anesthetic, ordinarily with good relaxation. In certain cases ether has to be given as a supplement but only for the terminal part of the procedure. Vinethene is especially useful in an office or clinic practice, and is being used a great deal in adults as a preliminary anesthetic. There is very little post-anesthetic nausea, vomiting or excitement, and the toxicity of the drug is very low. In this respect it markedly differs from ethyl chloride, which has to be used with great caution and for only a short time. In older children novocaine as a local anesthetic can be used, but usually this type of anesthetic is not suited for youngsters or infants.

The various steps in the application of the retention cast are shown in the accompanying photographs. The fracture is usually better reduced before the plaster of Paris cast is applied, although in one

instance I found it more advantageous to put on the plaster cuff first. After reduction the metal stirrup is incorporated in the

belt can be tightened up until enough pressure is obtained to keep the supracondylar fragments in alignment with the



FIG. 1. Stockinet and anterior felt pad applied, the latter  $\frac{1}{2}$  to  $\frac{3}{4}$  inch thick. This is usually sufficient to prevent untoward pressure symptoms. (The adhesive strips are only to hold the felt in place for the photograph.)



FIG. 2. Plaster cuff applied. This need not be thick or bulky.

plaster cast. Which order to follow will depend on the individual case and whether the plaster cast will in any way interfere with the manipulation of the fractured fragments.

Figure 1 shows the stockinet and anterior felt pad applied, the latter being  $\frac{1}{2}$  to  $\frac{3}{4}$  inch in thickness, which usually is sufficient to prevent untoward pressure symptoms. (The adhesive strips are only to hold the felt in place for the photograph.) Figure 2 shows the plaster cuff applied; this need not be very thick or bulky. Figure 3 shows the duralumin metal U splint, which is shown incorporated in the plaster cast. In my three cases I used a duralumin Böhler walking stirrup with the rubber walking tread removed and the side arms cut down to the desired length. The bottom of the bar should be about two fingerbreadths below the olecranon process. Figures 4, 5 and 6 show different views of the leather belt, which is looped around the arms of the splint. Between the anterior loop of the belt and the supracondylar aspect of the elbow is placed a thick piece of the felt. This is a necessary precaution in order to prevent too much pressure on the underlying structures. The

proximal shaft fragment. With the arms of the metal splint placed slightly anterior to the line of the condyles enough space is allowed for the desired pressure to be applied by the belt. If the stirrup has been



FIG. 3. Duralumin metal U splint incorporated in plaster cast.

applied too far posteriorly and the belt flattens out too much when pulled tight, added felt strips may be applied which will put the pressure surface further posteriorly. This will increase the effective pull or pressure of the belt. Either fluoroscopic or x-ray control combined with clinical check-up will be necessary to determine when sufficient reduction and immobilization has been obtained.

The extremity is best carried in a sling with the elbow at a right angle, although



more or less flexion may be obtained if desired. In one case I used just a sling around the wrist, which embodies the swelling appears or other undesirable signs or symptoms are seen the belt should be loosened and the elbow extended some-



FIG. 4. Posterior view of the apparatus with the leather belt in place.

FIG. 5. Lateral view of the apparatus.

principle of the gravity pull method. The movement of the forearm at the elbow has no effect whatever on the fractured part if adequate pressure is obtained by means of the apparatus. The triceps pull will naturally tend to displace the distal frag-

ment. I have found that the belt can be tightened or loosened during the first few days after reduction without the patient's experiencing much of any pain.

The follow-up on these cases entails nothing unusual. The apparatus gives excellent protection to the involved region from falls or blows by playmates and others. I have noticed much less complaint from such minor traumata from these three patients so treated than from the ones I have had up in Jones or Ashhurst bandages or in moulded plaster of Paris splints.

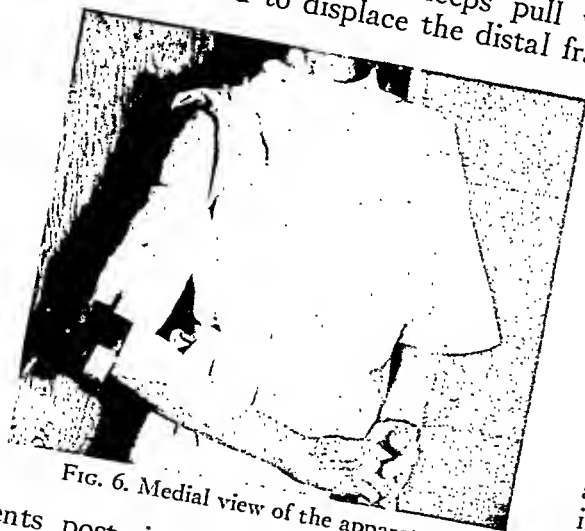


FIG. 6. Medial view of the apparatus.

ments posteriorly and upward, but this can be lessened by having the elbow in the mid position between right angle flexion and extension.

A careful watch must be maintained for signs of circulatory or neural involvement, and the extremity should be elevated on one or two pillows for a few days after reduction, during which time the patient had better be kept in bed. If any dangerous

#### CASE HISTORIES

CASE 1. A 12 year old boy sustained a supracondylar fracture of the right humerus in a fall from a bicycle. Figures 7 and 8 show the anterior-posterior and lateral views of the injury. The fracture was reduced one hour or so after injury under general anesthesia and put up in the Jones position. The following day the bandage had to be loosened somewhat due to circulatory impairment from swelling about the elbow. X-rays taken at this time showed some posterior and upward displacement of the lower fragments. The patient was re-anesthetized and the fracture reduced and held in alignment by the author's method. The cast and splint were removed in four and one-half weeks, during which time there had been no circulatory involvement. A partial radial palsy was noticed shortly after the injury and has gradually

improved. Figures 9 and 10 show the condition of the involved member about three months later. The motions of the elbow at this time

her right upper extremity. She sustained a Colles fracture of the right wrist and a supracondylar fracture of the right elbow, involving



FIG. 7. Case 1. Anteroposterior view of the elbow before reduction.



FIG. 8. Case 1. Lateral view before reduction.

were from 110 to 70 degrees. The anteroposterior view shows more of a varus condition than was clinically discernible. When last seen, five months after the accident, the patient had a moderate degree of varus deformity. The motions were from 155 to 55 degrees, and he was active in all manner of sports. He had still some radial nerve involvement, which was continuing to improve slowly.

This patient's nerve injury was thought to be due to a direct trauma at the time of accident and was not caused by any ischemic complication. At no time was the swelling of the involved part great enough to produce any numbness, blueness, edema or coldness of the fingers, whereas the original x-ray clearly shows the great amount of displacement and jagged edges of the fragments.

**CASE II.** A 13 year old girl fell from a limb of a tree eight feet from the ground, landing on

the lateral condyle with some posterior and outward displacement.

The patient was anesthetized about two hours after the accident, and the wrist reduced and held by anterior and posterior moulded plaster of Paris splints from the fingers to the elbow in the Cotton-Loder position of palmar flexion and some ulnar deviation. The elbow fracture was reduced, and another pair of 3 inch anterior and posterior moulded plaster of Paris splints were placed on the limb from the shoulder to the fingers, overlying the previously applied forearm ones. The elbow was placed at about 45 degrees flexion. Then a circular plaster cast with the incorporated duralumin walking stirrup was applied to the arm, according to the author's method. The pressure belt was placed directly on the posterior plaster splint which was well padded over the lower humerus. Post-reduction x-rays were taken through the plaster splints of the wrist and the elbow and

revealed excellent position of the fragments. This patient was watched very carefully for twenty-four hours. The elbow had to be let the posterior aspect of the humerus is tending to correct this misalignment. When last seen, ten weeks postoperatively, he had painless free



FIG. 9. Case I. Anteroposterior view three months post trauma.

FIG. 10. Lateral view of same case three months post trauma.

down from 45 degrees to 60 degrees during the night. However, no serious complaints developed. The entire immobilizing device was removed from the extremity exactly one month later and x-rays showed good position and firm bony union of the involved bones. The patient has done very well with complete return of motion and power in the wrist, but some limitation of motion in the elbow. She is left handed and it is a great task to get her to use the right hand. Motions of the elbow are from 140 degrees to complete flexion and she is getting along splendidly.

CASE III. A 6 year old boy was seen here for a malunited supracondylar fracture of the left humerus. The patient had sustained the injury about four weeks before entry. Open correction with osteotomy was done and the elbow immobilized by author's plaster cuff-metal stirrup method. The apparatus was removed four weeks postoperatively. The lateral view showed some posterior displacement of the lower fragment but new bony formation on

motion from 80 degrees to 120 degrees and was rapidly using the extremity for almost everything. This child is one of our State crippled children cases. Later on another osteotomy to get a better alignment of the lower fragment may be done. In this case, however, the cuff-stirrup retentive apparatus held the distal fragment satisfactorily without any neurological or circulatory disturbance.

#### SUMMARY

A new method of retention of the reduced supracondylar fracture is described, which has the following advantages: (1) It is a closed method. (2) It is easy and simple to apply. (3) It adequately holds the elbow in place and the pressure on the distal fragment can be easily increased or decreased as desired. (4) It allows free motion of the elbow. (5) There is no constricting device in the antecubital region.

# SUBMUCOUS HEMORRHOIDECTOMY

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**H**EMORRHOIDECTOMY is one of the most universally performed operations in the realm of the surgical specialties. An important predisposing factor in the etiology of hemorrhoids in women is the increase in intravenous pressure by the gravid uterus. Prolonged labor and difficult delivery aggravate this condition. In my gynecologic practice I had often been requested by patients to remove existing hemorrhoids while repairing lacerations of the pelvic floor. This I refused to do for fear of unduly prolonging the time of the operation, and because of my reluctance to expose the patient to the additional suffering which accompanies the usual hemorrhoid operations.

Because of these objections, I searched for an operative procedure which would meet the following conditions:

1. The method should restore the anal and lower rectal region to as near normal as possible, with no complicating postoperative stricture.

2. The operation should be as free from postoperative pain and hemorrhage as possible.

3. It should be simple of execution so that it could be performed with the least possible trauma and in the shortest possible time.

I feel that I have devised a modification of the ligature and excision technique, a simplified submucous hemorrhoidectomy, which fulfills these requirements. In order that one may be able to evaluate the advantages that this method has over the older operations, a fair acquaintance with the pathogenesis of hemorrhoids is necessary.

From the various descriptions of the pathology of hemorrhoids by Brav,<sup>1</sup> Fleischer,<sup>2</sup> Montague,<sup>3</sup> and Buie,<sup>4</sup> the following

brief résumé is sufficient to acquaint one with the subject. The hemorrhoidal plexus of veins is the primary seat of this disease and the rectal mucosa is only secondarily involved. The pathologic changes begin with the formation of varicosities in the veins. The increase of the local intravenous pressure arising from constipation, excessive use of laxatives, straining at stool, pregnancy and tumors, produces venous congestion with marked tortuosity of the veins. The walls of these vessels become thinned out, stretched and sacculated. The mucosa overlying such veins becomes attenuated and is loosened from its submucous attachment. The injured vessel with its surrounding areolar tissue and the redundant mucosa form a sacculated mass which on further stretching may eventually become pendulous and protrude through the anal orifice forming what is called a prolapsed hemorrhoid. These varicosities encroach on the lumen of the lower bowel so that the passage of hard fecal masses traumatizes the tissues, causing abrasions and ulcerations of the thinned out mucosa. This process may affect the blood vessels and lead to bleeding, a common symptom of hemorrhoids. Such open wounds, present in an area where pathogenic organisms abound, may easily become infected, resulting in round cell infiltration and chronic inflammatory changes of the vessel walls. Occasionally thrombosis of the veins takes place; the clots may be completely absorbed or they may break through the vessel wall and be extruded. In other instances sclerotic perivascular changes occur in the areolar tissue supporting the veins, thus bringing about the complete occlusion of the vessels. These same pathologic changes take place where external hemorrhoids are present

except that instead of the mucosa being involved it is the skin that covers the varicose or thrombotic veins.

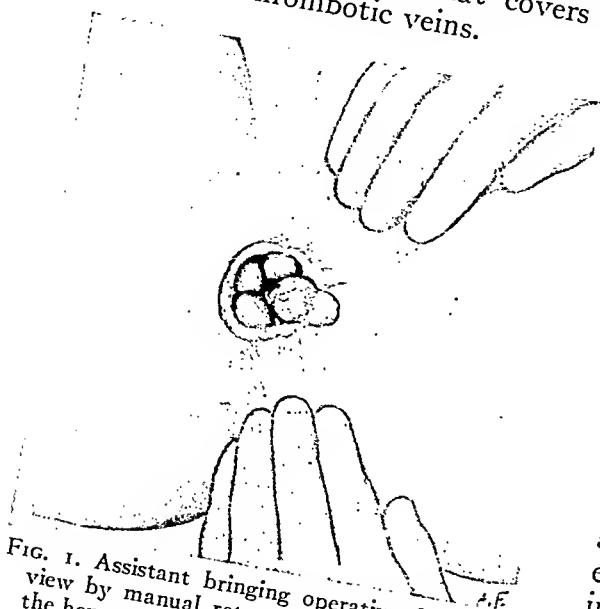


FIG. 1. Assistant bringing operative field into view by manual retraction thereby exposing the hemorrhoid in the process of excision.

#### TECHNIQUE

The method which I employ is based on a sound conception of the pathologic changes encountered in the lower bowel. None or very little of the rectal mucosa is

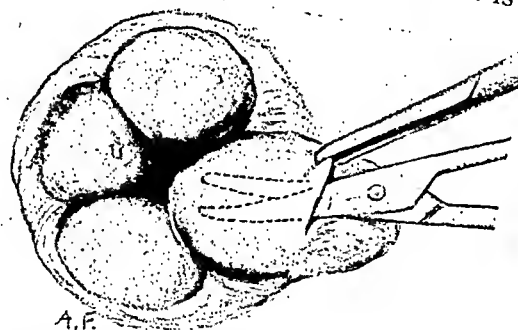


FIG. 2. Transverse incision at mucocutaneous junction and mobilization of rectal mucosa covering hemorrhoidal mass.

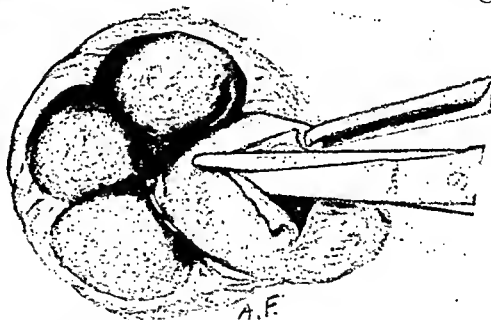


FIG. 3. Longitudinal incision along midline of mucosal flap exposing underlying hemorrhoid.

omy position. Otherwise, local anesthesia of 1 per cent novocaine injected around the anal ring will render the operation completely painless.

In dealing with internal hemorrhoids alone, I proceed as follows: No preliminary dilatation of the sphincter ani is undertaken. This is definitely contraindicated, for it causes traumatism to the sphincteric tissues. It is unnecessary, since the sufficient exposure of the diseased area is readily accomplished by the more gentle manipulation further described.

With the assistant bringing the operative field in view by proper manual retraction (Fig. 1), a small transverse incision is made at the mucocutaneous junction of the exposed hemorrhoid. The free edge of the incised mucous membrane is grasped gently with tissue forceps or Allis clamp, and with a small blunt curved flat-blade scissors the mucous lining is undermined along the entire length and width of the underlying hemorrhoidal tissue. (Fig. 2.) This is followed by a longitudinal incision with a blunt straight scissors along the midline of the mobilized flap, thus exposing the hemorrhoid in its entirety. (Fig. 3.) A

sacrificed; only the diseased veins with the supporting perivascular areolar tissue are removed.

As the patient is being operated upon for some defect in the genital structures about the pelvic floor she is already under some form of anesthesia and in the usual lithot-

No. 00 plain catgut suture on a small curved round needle is passed around the distal end of the hemorrhoid and ligated. (Fig. 4.) This suture will not be absorbed before two or three days, which is long enough to prevent oozing and render the operation almost bloodless. A small hemo-

stat is placed in front of the suture-ligature and the hemorrhoid is removed with either knife or scissors from its submucous bed,

and sutures cause constriction and breaking down of tissues.

When external hemorrhoids are also

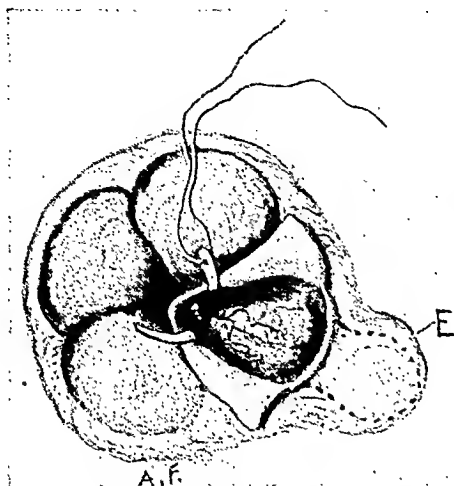


FIG. 4. Suture-ligature passed around distal end of hemorrhoid. E, outline of portion of external hemorrhoid to be removed.

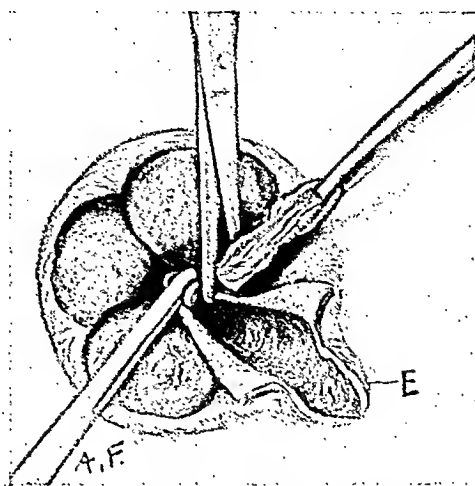


FIG. 5. Excision of internal hemorrhoid. E, external hemorrhoid removed.

care being taken to cut in front of the hemostat and not beyond the ligature. (Fig. 5.)

The operative field is now covered with two flaps of mucosa. (Fig. 6.) Should these be too redundant, they may be easily trimmed to the desired width, always remembering that it is better to leave behind an excess of tissue rather than too little. If the rectal mucosa is ulcerated, as when dealing with ulcerated hemorrhoids, the diseased portion must be trimmed off in order to insure proper union of the flaps. These are not sutured together but are left free to agglutinate to the underlying raw surface. This process takes place very soon, usually within the first three or four days after the operation.

In a number of mild cases of hemorrhoids I omitted the suture-ligature around the base of the hemorrhoid and, instead, allowed the hemostat to remain in place while removing the hemorrhoid in the manner above described. No bleeding took place after the removal of the instrument. The clamping of the veins for a short time sufficed to prevent bleeding. This adds another important feature in favor of this operation, since ligatures act as irritants,

present, I proceed in a similar manner by mobilizing the skin covering the external hemorrhoid before removing the mass. A sufficient v-shaped portion of the redundant skin is excised, care being taken not to remove too much. This prevents the formation of an ectropion. (Fig. 5E.) The

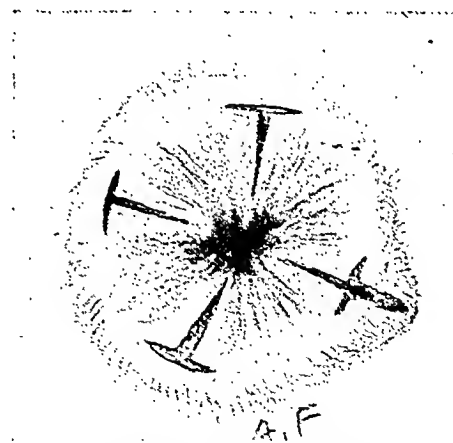


FIG. 6. Operative field after hemorrhoidectomy is concluded.

edges of the skin flaps, like those of the mucosa, are not sutured together. They are left free to agglutinate and usually heal within seven to eight days.

As a rule there is no bleeding from the internal hemorrhoid wound, although there may be just a slight ooze which soon ceases spontaneously. Should there be more than

the usual amount of bleeding from the external hemorrhoid wound, a dry gauze pad held tightly by adhesive strips will stop the oozing effectively. No elaborate perineal dressing is required, just a sterile gauze pad, to be changed when soiled.

Rarely do patients complain of any marked postoperative pain. Should this occur, a hot water bag over the perineum will give quick relief, and in extremely nervous patients a hypo of morphine may be resorted to.

The older methods of hemorrhoidectomy commonly used, the ligature-with-excision and the clamp-and-cautery operations, do not meet with the conditions stipulated above. The clamping off of a large portion of the rectal mucosa with the underlying hemorrhoid, followed by excision of the mass with or without cauterization, leaves behind a large raw surface. Healing takes place slowly by granulation and scar formation. If several hemorrhoids are removed at the same time, the resulting scars may be so extensive as to constrict the lumen of the bowel and form a rectal stricture, a complication noted by Tice.<sup>5</sup>

Severe postoperative pain is usually present for a long time on account of the reaction following the constriction, traumatization and burning of the tissues by the use of the ligature and the clamp and cautery.

Frequent primary postoperative hemorrhages occur because of the wide granulating surfaces remaining after these operative procedures. Such open exposure may lead to bacterial invasion and severe secondary hemorrhage, as noted by Pennington<sup>6</sup> and Barnes<sup>7</sup> and also by Gabriel<sup>8</sup> in his review of a series of 438 hemorrhoidectomies.

The after-care of these cases is governed by the type of operation originally performed on these patients. Where no rectal stricture exists, I use the following routine: I do not constipate my patients for any length of time after the operation. I prescribe a tablespoon of mineral oil to be taken morning and evening for several days

beginning with the first postoperative morning. The patients are allowed the use of the bedpan or toilet as soon as the desire for defecation arises. Many patients move their bowels on the second postoperative day with hardly any pain or bleeding.

As to diet, I prescribe liquids for the first day only, followed by a soft diet until the initial movement, after which a regular diet is resumed. It is with great difficulty that I can keep patients in the hospital for longer than three days, for they feel too well to be confined to bed. As a rule I allow them out of bed on the second postoperative day.

There have been no complications in the present series of more than 100 cases. So far, no postoperative hemorrhage requiring special attention was noted. Should this occur, the bleeding point can readily be located and a suture-ligature applied.

Not a single case of stricture of the rectum has occurred up to the present. This can be explained by the fact that the raw surface remaining after the excision of the hemorrhoidal mass is not allowed to granulate and form scar tissue. The two flaps of healthy mucosa or mucosa and skin covering the raw surface agglutinate promptly. The edges unite rapidly and leave only a very fine longitudinal scar hardly visible or palpable six months after the operation.

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# RENAL HYDATIDOSIS\*

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**R**ENAL hydatidosis, a disease produced by *Taenia echinococcus*, has a low incidence, is not benign, and has been known for the past thirty years through publications. The history of its development falls into three periods: (1) the clinical period; (2) the operative period; (3) the period of pyelography.

## ETIOLOGY AND PATHOGENESIS

### 1. Circumstances Determining Location.

(a) *Frequency.* Nicaise and other authors have reported percentages below the normal 3 per cent. The countries most affected are Algeria, Iceland, New Zealand, Dalmatia, and above all Uruguay and Argentina in South America. My own contribution is represented by twenty-nine personal cases, which form the largest group in medical literature thus far.

(b) *Path Traversed by the Parasite.* The arterial route is the most logical and probably the only one.

(c) *Primary location.* The cyst is located primarily in the kidney, since in general there is no concomitant lesion in other viscera. Secondary location is exceptional.

(d) *Single Cysts.* In general, just one cyst is present, but in exceptional cases the cyst may be multiple or affect both kidneys.

2. *Topography.* The entity hydatid cyst plus the pericystium and its parent membrane have important relationships which I have been the first to stress.

(a) *Relationship to the Renal Structure.* Since the cyst originates in the territory of the cortical zone and never in the pyramidal region, it reproduces the forms of the visceral cyst of the liver, destroying the elements of the kidney by the two

processes of distention and congestion plus toxemia. Its favorite site is the polar regions and it invades them up to the renal periphery and to the pyelic cavities, where it opens.

Indeed, once the cyst appears in the renal periphery, it will be possible to note that the claim of all authors who have wished to consider the cyst as attached to the kidney (from which it could easily be distinguished) is not justified, since it has been possible to ascertain the following facts:

1. It is impossible to find a line of cleavage which determines where the kidney ends and the cyst begins.

2. There exists a parenchymatous zone which invests and accompanies the pericystium for its entire length.

3. This pericystium is at the same time invested by the renal capsule, as proved by two things: in the first place, the cyst is always intrarenal; in the second place, the cyst is always infracapsular.

Although other authors consider that the cyst is not invested by the renal parenchyma (Fig. 1), my own view is that the cyst is invested by the renal parenchyma and also by the renal capsule. (Fig. 2.)

(b) *Relationship to the Pyelic Cavities.* Contrary to current reports, the cyst never opens directly into the pelvis of the kidney without having its base always resting upon the end of a primary calyx through a solitary and small hole of communication. As a result of this, we note a special aspect of the cyst: the aspect which will give rise to the pyelographic indication which I have called the "goblet sign." This sign consists in a large oval cavity represented by the pericystium, with one base

\* Read before the Urological Section, N. Y. Academy of Medicine, Feb. 16, 1938.



of support upon the extremity of the primary calyx, and with one support represented by this primary calyx.

occur early, and they involve the parenchyma *in toto*, a fact which explains the functional alteration of the organ.

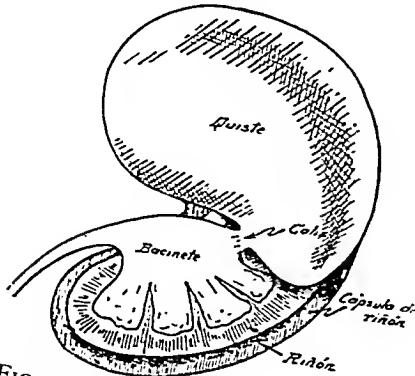


FIG. 1. Classic anatomopathologic picture of a renal hydatid dist. The cyst is covered neither by the kidney nor by the capsule.

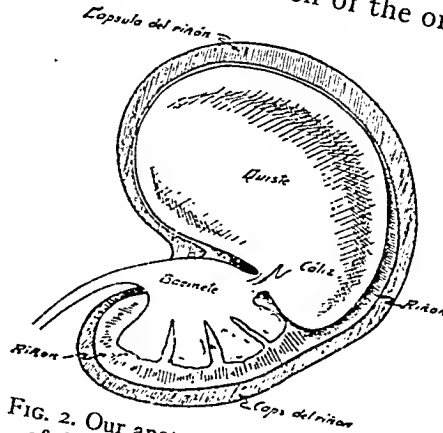


FIG. 2. Our anatomopathologic picture of the same condition. The cyst is always intrarenal and infracapsular.

The goblet sign may be identified as follows: the pericystium rests upon the extremity of one calyx, which serves as

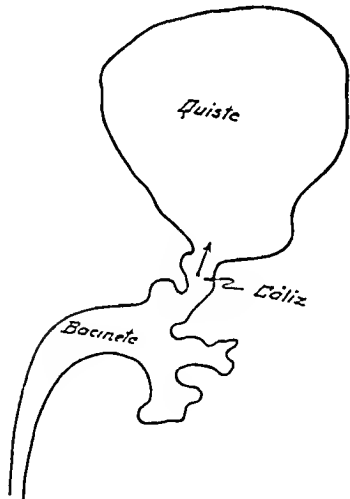


FIG. 3. The cyst opens out at the extremity of the primary calyx, giving the goblet sign.

support to it and assumes the shape of a goblet. (Fig. 3.)

#### PARENCHYMAL LESIONS

These lesions are important, they can be traced around or far from the cyst, they

#### ANATOMOPATHOLOGIC DEVELOPMENT OF THE CYSTIC SACS

The cystic sacs are frequently regarded as similar to hydropyonephrosis. This, however, is a mistake, for two reasons: (1) the sacs in hydropyonephrosis represent permanent lesions which have no tendency to regress once they have ruptured; (2) on the other hand, once the sacs of a hydatid cyst have burst, they tend to recede, to shrink, and to disappear by fibrous transformation. It is for this reason that I wish to stress the fact that it is not rare to see enormous cysts which had occupied the entire abdomen transformed into small stumps as soon as they have been drained.

#### SYMPTOMATOLOGY

Renal hydatidosis presents the characteristics of hydatid diseases: slow, progressive, and insidious development; destructive development; and tendency toward infection. Its symptomatology is characterized by tumefaction; functional urinary changes, and general functional changes.

The tumor itself is globular, rounded, not pitting, sometimes fluctuating and sometimes like parchment in consistency,

and on rare occasions gives the sensation of a thrill.

When the symptoms are thoracic and

exaggerated and there appears the classic triad of hydaturia, nephritic colic, and accordion-shaped tumor.



FIG. 4. A calcified closed cyst, showing the goblet sign.

abdominal, the hypochondrium is apt to be involved. When the symptoms are abdominal, the flank is apt to be involved.

A cyst of the spleen should not be confused with a renal cyst because the former never arrives inside the angle of the colon. We should further point out that the splenic cyst usually displaces the angle of the colon which never occurs with a renal cyst.

The characteristic feature of renal cystic tumefactions is that the kidney generally loses motility, because the renal cyst, contrary to present claims, soon adheres to the lumbar fossa.

*The urinary functional changes* are always present. When we are dealing with a closed cyst they are evidenced by microscopic hematuria and functional alteration of the kidney. When we are dealing with an open cyst the above symptoms are

#### DIAGNOSIS

We are faced with three possibilities in differentiation: (1) a renal tumor; (2) a cystic tumor; (3) a closed or open cyst. I shall stress here only the two main syndromes: the biologic and the pyelographic.

*Biologic Syndrome.* Urticaria is very rare. Laboratory tests reveal the following: Eosinophilia ranges between 3 per cent and 10 per cent and can reach 20 per cent in rare cases. However, this point has no absolute value, since it is not evidenced when the cyst is dead and calcified, and may also occur in other diseases. I have found it in 30 per cent of my cases of renal tumors. Cassoni's anaphylactic reaction is found in 60 per cent of the cases, but it may also be present in renal cancer and in neoplasms of the lung. Weinberg's reaction is found in 40 per cent of the cases.

**Radiographic and Pyelographic Syndrome.**  
Simple radiography may be of diagnostic aid in two circumstances: (1) in the pres-

4.) (2) When there are spots in the kidney region; their value is purely one of presumption.

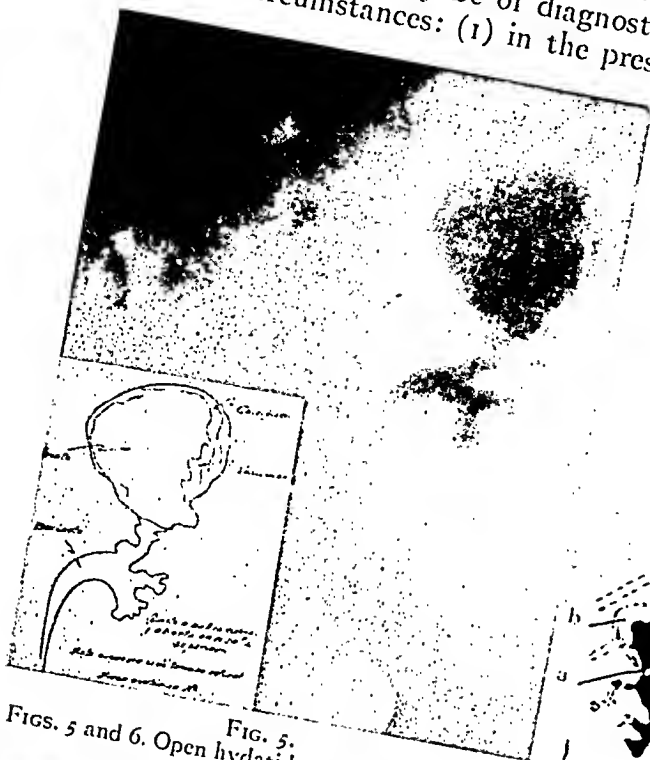


FIG. 5.

Figs. 5 and 6. Open hydatid cyst, showing the goblet sign. (Note the rounded shadows on the inside of the goblet, which correspond to the daughter vesicles.)



FIG. 6.



FIG. 7. Open hydatid cyst and goblet sign.



FIG. 8. Open renal cyst with pyelogram showing crescent sign.

ence of calcified cysts which are shaped like a goblet or pear and appear in the renal area; this sign is of great value. (Fig.

Pyelography settles the clinical diagnosis and gives picture of the cyst in two eventualities. We are sure of the diagnosis when

we find: (a) what I call the "goblet sign," a broad image resting upon a calyx and taking the form of that calyx. (Fig. 5.)

consideration may be given to amputations of the calyces and displaced ureters mentioned in the literature.



FIG. 9. Open renal cyst with pyelogram showing cluster of grapes sign (honeycomb sign).



FIG. 10. Renal cyst with pyelogram showing horizontal level sign.

The center of the image may be distinct and uniform, or may present a succession of light and dark zones showing rounded regions corresponding to daughter cysts. (Figs. 6 and 7.) (b) *The sign of the crescent* or segment of a moon is of enormous value, and must be distinguished from false crescents (constituted by curvatures of the ureter). (Fig. 8.) (c) *The sign of the bunch of grapes or honeycomb*, the image given by the daughter cysts. (Fig. 9.) (d) *The horizontal level sign* indicates an air cyst of the kidney. This is the only case known to medicine. (Fig. 10.)

These pyelographic data are of fundamental importance, and when the findings present the appearance noted they are pathognomonic of the disease.

The diagnosis may be questioned in certain circumstances: (a) In the case of a ruptured cyst: when there are deformities limited to one calix and simulating crescents; when the rounded appearance of the cyst is outlined; when the areolar aspect is seen to be confined to one calyx. Apart from this, I do not believe that important

In a closed cyst: where a shadow coincides with the cupola of a calyx; where displacements caused by torsion of the kidney make it appear that the kidney is supporting something, the existence of a cyst may be suspected.

#### PROGNOSIS

The above mentioned views regarding pathologic anatomy, which show the occurrence of renal destruction, force me to contradict the present views. I believe that a hydatid cyst means an affection endangering the kidney.

#### TREATMENT

Early treatment and conservative surgery are indicated for hydatid cysts. They must be treated at an early date because their development is progressive and destructive. Surgical treatment must be conservative because they remain a polar affection for a long time, and, above all, because, as I pointed out before, cystic sacs tend to regress and to shrink once

they have burst, being transformed into fibrous stumps.

Nephrectomy is radical treatment. Conservative treatment is constituted by partial nephrectomy, excision of cysts and closure without drainage, and marsupialisation. In practice, we must decide between nephrectomy and marsupialisation.

Nephrectomy is necessary when marsupialisation is contraindicated; it is obligatory in complete destruction of the kidney; in multiplicity of cysts in the same kidney; in calcified fatty cyst, even when the kidney has not suffered much destruction; and when conservative surgery has not succeeded.

In nephrectomy we must not forget that the cyst is always intrarenal and infracapsular, as I have pointed out, and therefore the operation will have to be performed by the infracapsular route (which is easy, possible, and not dangerous). On the con-

trary the operation is very difficult and very dangerous when, for any reason, it is done by the extracapsular route.

Marsupialization must be borne in mind in all cases; it is also necessary: (1) as a preliminary to total nephrectomy; (2) when required by the patient's condition. It has been unjustly criticized because of the long duration of the fistula. However, I have always seen the fistula disappear within three months whenever the cystic sac was not attached to the wall.

#### CONCLUSIONS

Renal hydatidosis is a disease whose development is intrarenal and infracapsular, whose diagnosis is determined by pyelographic signs (goblet sign, bunch of grapes sign, crescent sign, and horizontal level sign), whose prognosis is bad, and which it is not always easy to treat.



# THE INJECTION THERAPY OF HYDROCELE AND SPERMATOCELE\*

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IN medicine as in industry, simplicity, conservation, and economy represent the acme of attainment in any given procedure. To this end, injection therapy for varicosities, herniae and pathologic processes in endothelial-lined sacs has enjoyed widespread application in recent years. This brief exposition will concern itself with a new pharmacologic agent for injection treatment of hydrocele of the tunica vaginalis and spermatocele.

Medical healers from time immemorial have wrestled with the problem of hydrocele. Celsus, in ancient Rome, essayed eradication of the sac by injecting saltpeter and by surgical excision of a portion of the sac. Various surgical procedures from exteriorization to total enucleation of the cystic mass were subsequently tried with varying results. Down the ages, various sclerosing solutions have been used, a partial list including tincture of iodine, phenol, sodium chloride, quinine urea hydrochloride, sodium morrhuate, quinine dihydrochloride and a host of other combinations of drugs.

Injection therapy fell into disrepute several centuries ago due to the untoward painful inflammatory processes set up by the extremely powerful sclerosing agents used. True, results were attained, but at too great a price. Consequently, the pendulum swung to surgical correction of the deformity to the exclusion of all other forms of therapy.

Within the past decade, however, a more rational approach to the use of sclerosing agents for injection has been made. The accumulated data obtained from varicose vein therapy have been applied to hydro-

cele. This is a condition which claims 2 to 4 per cent of all urologic admissions to clinics and hospitals, according to Ewell, Marquardt and Sargent.<sup>1</sup>

The late Dr. Norman J. Kilbourne and Dr. C. J. Murray<sup>2</sup> expounded the following requirements for the ideal injection solution:

1. It must not cause immediate pain at the time of injection.
2. It must not cause pain several hours after injection.
3. It must not cause undue local inflammatory reaction disabling the patient. He must not be kept from his regular work or lose time.
4. It must be bactericidal. If it is strongly bactericidal, the possibility of infection is eliminated.
5. It must not be dangerously toxic.
6. It must be efficient in destroying even large hydroceles with thickened walls, and yet it must not be so caustic as to bring on hemorrhage into the sac. This was reported in the old days with strong phenol concentrations.

After experimenting with eucupin, a quinine derivative, and quinine hydrochloride with urethane, Kilbourne added diothane as an additional anesthetic agent. It is this solution of quinine hydrochloride, urethane and diothane which forms the basis for our work. It was successfully applied in twenty-eight consecutive cases in the hands of Kilbourne,<sup>3</sup> but further confirmation was desired. At the suggestion of, and in collaboration with Dr. Clarence G. Bandler, who was one of the first to show the merits of diothane as an effective mucosal surface anesthetic agent in urol-

\* Read before the Section of Genito-Urinary Surgery, New York Academy of Medicine, April 20, 1938.

ogy,<sup>4</sup> this work was undertaken. The fundamental technique of Kilbourne was followed.

above mentioned drugs in the following proportions:

	Per Cent
Diothane.....	0.75
Quinine HCl.....	5.5
Urethane.....	3.0

The research product has been issued in 10 c.c. ampules, represented as a clear, colorless solution. Any discoloration in the solution should be a contraindication to its use.

**NATURE OF NEW PREPARATION\***

Let us consider the constituents and rationale for the inclusion of the three drugs mentioned in the injection solution under consideration. Quinine hydrochloride is an irritant that has bactericidal as well as anesthetic properties. This gives it preference over sodium morrhuate which is said to be non-bactericidal and painful on injection. The objection to quinine on a basis of idiosyncrasy or toxicity is a valid one. Auditory and optic nerve impairment has been reported after as little as 15 gr. of the drug had been taken. Since the content of quinine hydrochloride in this solution is only 5.5 per cent, a maximum of 10 c.c. would contain only 0.5 Gm. or 7.5 gr. The average dose used for injection in our hands was 6 c.c., representing 5 gr. No evidence of quinine sensitivity has been reported by any of the observers using this preparation.

Urethane is anesthetic in itself and also enhances the action of quinine, promoting its solubility, facilitating its penetration into the endothelial lining of the hydrocele sac, and most important, preventing a strong local inflammatory reaction. According to experimental work of Kilbourne, this latter property is an apparent specific action of urethane with quinine.

Diothane, a phenyl urethane synthesized by Rider,<sup>5</sup> has a powerful prolonged local anesthetic action and further enhances the effect of the solution. A noteworthy finding has been the total absence of pain from the injection per se. Naturally, rough handling of the scrotum and testicle will produce pain and striking the testis or cord structures with the needle during aspiration or injection may give excruciating pain. We have noted no post-injection discomfort.

Rider, of Merrell and Company, has provided a simple stable solution of the

The complete eradication of pain represents an accomplishment which has long been sought. Even in recent contributions to the literature we note references to this lone disturbing factor. Mayers,<sup>6</sup> in reporting on twenty-three successes using quinine hydrochloride and urethane states "an almost constant reaction at the time of the first injection is rather sharp pain." Baretz<sup>7</sup> reported twenty-nine, or 70 per cent cures in forty-two cases, with several patients complaining of pain at the time of injection of the quinine and urethane solution he used. While this pain never incapacitated, discomfort was experienced in some cases for one to two days. Kilbourne used quinine, urethane and diothane in twenty-eight cases without any pain and we have used it in twenty-six instances without such sequelae.

#### TECHNICAL PROCEDURE

Several points in the technique of aspiration and injection of hydrocele or spermatocele are worthy of note. The patient is placed in a supine position, the scrotal area prepared and surface antiseptic applied. We favor shaving the patient, both to combat infection and to facilitate application and removal of an adhesive suspension. A small wheal is raised at the site of injection, using 1 per cent procaine hydrochloride. Kilbourne has emphasized the necessity for using a 3 inch 17 gauge needle for aspiration.

Various observers have advised special trocars and taking particular care in reversing the direction of the needle as it is pushed through the scrotal wall, thus

\* The drug was supplied by the William S. Merrell Company of Cincinnati.



preventing leakage after its withdrawal and also helping to prevent it from slipping out of the sac. We followed this latter step, as advised by Kilbourne, in order to duplicate his technique exactly so that results could be evaluated. In recent cases we have simply used a 2 inch 19 gauge needle, inserting it almost at a right angle to the skin surface and directing it toward the upper recess of the sac—away from the testis and epididymis and parallel to the cord. We have noted no extravasation or leakage as a result. Care must be taken to keep the needle in place and we insert it, where possible, to its hub. In one instance, about 1 c.c. of the sclerosing agent was placed in the scrotal wall when the needle did slip out, but there was very little tissue reaction and no pain whatsoever.

Of great importance is the thorough evacuation of the sac. Depending on the size of the sac, a 10, 20 or 50 c.c. syringe may be attached to the needle for aspiration. Another 10 c.c. syringe filled with the drug is held ready for attachment to the needle. It is not sufficient to consider the sac empty when no more fluid can be aspirated. Digital palpation, "cornering" the fluid in the upper recess where the needle point lies, and manual expression without the syringe attached to the needle, will often yield 10 to 20 c.c. more fluid. It is readily understandable how ineffectual this amount of hydrocele fluid, if left behind, would render the sclerosing material.

Assistance makes the entire procedure easier, but we have carried it out single-handed, in both the clinic and the office. Depending on the amount of fluid obtained, a proportionate volume of the drug is injected. Thus, 2 c.c. was injected into a sac from which 15 c.c. of fluid was obtained; 300 c.c. of fluid was replaced by 10 c.c. of the drug. The dose is arbitrary—the aim being to inject enough to reach the entire endothelial lining of the sac. This brings up another important step in technique—that of "kneading" the collapsed sac following injection, to facilitate uniform distribution of the drug.

Finally, we favor a measure which has not been employed or emphasized by others. We apply a snug, adhesive suspensory immediately after the injection. This is kept on for three to five days without being disturbed. Following its removal a bag suspensory is worn until cure is effected. We believe the immediate compression of the collapsed sac enhances the action of the drug on the endothelial surface. Further, after the first week, nightly hot sitz-baths are advised to promote speedier resolution of the fluid accumulation.

#### ANALYSIS OF CASES

Our particular study embodied a total of nineteen hydroceles and seven spermatoceles in twenty-three patients, whose ages ranged from 4 to 75 years. Thirteen, or 60 per cent, were over 50 years of age. Fifteen patients, representing thirteen hydroceles and four spermatoceles, have been followed through to apparent cure and have been observed for follow-up periods varying from one to fourteen months. It is this group which forms the basis for our observations and conclusions.

Some of our cases represented clinic material, and because of the migratory nature of the adult male patient, we have seven incomplete records. We wish to express our indebtedness to Dr. J. A. Hyams for making such material available in the Urologic Out-Patient Department of the Gouverneur Hospital, and to Doctors D. A. Anderman and S. Klein for their clinical assistance. Private cases are also included in the study.

A brief analysis of the seventeen completely followed apparent cures in fifteen patients yields some interesting data. In all except one case, definite etiology could not be elicited and they were therefore classified as idiopathic. One followed partial phlebectomy for varicocele. The size of the hydrocele or spermatocele as determined by fluid content varied from 4 to 300 c.c. and the amount of quinine hydrochloride, urethane and diothane injected ranged



from  $\frac{3}{4}$  c.c. to 10 c.c. The cases were consecutive and unselected.

Injections were made from one to four weeks apart. The number of injections necessary for final eradication of the sac was: in nine cases, one injection; in five instances, two; and three, four, and five injections, respectively, were necessary in three remaining cases. In the early cases we were too anxious to effect a rapid cure. We have since learned to wait at least three weeks between injections, for little is gained by repeated rapid injection therapy. We feel certain that the next group of cases in this series will show far fewer injections per case.

The aspirated fluid is routinely examined microscopically. The hydroceles yielded clear yellow fluid on initial aspiration and subsequent post-injection specimens were either clear, hazy or deep orange in color. Spermatoceles yielded pathognomonic milky fluid. Following injection and with diminution in the fluid content of the sac, a characteristic crepitan sensation is elicited, not unlike a pleural friction rub. This finding is evidence of effectivity of the drug and bodes well for ultimate cure. No infection, local or systemic reaction was noted in any of the cases following injection therapy. Several workers have cited this point as a contrast to operative figures published by Campbell<sup>8</sup> in reviewing 502 open operations for hydrocele. He noted a 15 per cent incidence of superficial or deep infections. Six patients developed uninfected and twelve infected hematoceles, eight of the latter resulting in orchidectomy. Despite a total of thirty-one injections, we did not have a single case of hematocele.

Of the seven cases listed as incomplete, three did not return to the clinic and investigators could not locate them. Two were more recently injected. Two represented communicating hydroceles, ordinarily a contraindication to injection therapy. Care was taken, by using pad compression over the inguinal canal to prevent entry of the solution into the peritoneal cavity.

Injection in these cases was carried on from a purely academic standpoint, since operation was indicated and we were seeking histologic studies of the effect of the sclerosing drug on the endothelial lining of the tunica. Cures were not anticipated nor effected, but the patients have put off surgery—unfortunately. We have not classified these cases as true failures since we could not consider them suitable ones for injection therapy and would not have resorted to this course except with the hope of obtaining tissue studies.

#### SPERMATOCELE THERAPY

Of four spermatoceles, three were cured by one injection. A characteristic induration remains, varying from pea to olive-size. It apparently represents a contracted sac, for attempts at aspiration of possible fluid content have been unsuccessful. In two instances, the sacs were loculated and as many as three individual cavities on one side have been aspirated and injected at one sitting. Others have reported indifferent results in injection therapy of spermatocele. Our own few results are gratifying since the tendency of the lesion to recur even after surgical excision is well known unless the epididymis and rete testis are sacrificed.

An interesting observation was made in studying the fluid content of the spermatocele microscopically, before and after injection. Prior to treatment, the fluid contains swarms of actively motile spermatozoa. Subsequent examinations after injection show either very sluggish motility or complete cessation of activity and a diminution in numbers. The spermicidal action of the drug may explain this efficacy.

A possible explanation of the mechanism by which sclerosing solutions act has been advanced by Ewell, Marquardt and Sargent.<sup>1</sup> A patient who had been injected three times with quinine hydrochloride and urethane and cured, was prevailed upon to submit to operation one month later. Grossly, a normal testis and epididymis were found, together with a small amount

of dark amber fluid and several long loose strands of attached and organized fibrin. Microscopically, the endothelial layer was intact, the blood vessels appeared normal, but the subserous tissue of the tunica was distinctly thickened and infiltrated with organizing fibrous tissue. These workers advanced the hypothesis that fibrosis of the tunica wall after injection so interferes with the blood and lymph supply of the endothelium that it alters the process of fluid formation or absorption.

Others feel that obliteration of the sac is accomplished by adherence of apposing walls following a sclerosing inflammatory reaction. While this is apparently a logical theory, the sparse work on the subject does not bear it out. Further study along such lines is essential.

Without question, injection therapy is an ideal procedure for eradication of chronic hydrocele or spermatocele in the aged, the poor operative risk, in recurrent postoperative hydrocele or spermatocele, in hydrocele following partial phlebectomy for varicocele, in those who refuse surgery but will submit to office injections, and for that large group which, for economic reasons, cannot be hospitalized.

#### CONTRAINDICATIONS

Contraindications to injection therapy apply to the acute hydrocele which will usually subside with rest and immobilization, and to communicating hydroceles with or without hernia. It has been stated that without open operation, neoplasm or tuberculosis may be overlooked. If careful palpation is made of the scrotal contents when the sac is first emptied, such errors in diagnosis would not occur. Needless to say, all cases suspected of possible epididymal or testicular lesions should be explored.

With the advent of a nontoxic, non-irritating, effective sclerosing agent, such as quinine hydrochloride, urethane and diothane whose injection is free of pain, many of the previously reported complications of injection therapy of hydroceles may be obviated. Local and systemic reactions,

slough, infections, injury of testicle, epididymis or cord structures, and hematocele must now be attributed to faulty technique or to the drug. To avoid injury to a large scrotal vessel at the time of injection, we suggest the added precaution and refinement of placing a lighted electric light under the sterile draping at the time of injection to transilluminate the mass. We have used a Cameron light which can be sterilized and brought in direct contact with the scrotum.

The relative merits of aspiration and injection as opposed to open operation can only be determined by careful statistical comparison. Sanford<sup>9</sup> noted thirty, or 2.4 per cent relapses, in 1,216 cases of open surgery for hydrocele. Of these, there had been late investigation of 412 cases with twenty-two relapses, or 5.33 per cent. The same author revealed that 6 to 14 per cent failures had been reported following injection therapy, although conceding that with newer methods and drugs the percentage of failures is lower.

In evaluating recurrences after injection therapy, one must distinguish between fluid re-accumulation which may require one or more injections to eradicate, and true return of fluid after a period of apparent obliteration of the sac. Nor should one call a case a failure which does not respond to a single injection of the sclerosing solution.

#### CONCLUSIONS

We are presenting our data as a preliminary report, with final evaluation deferred, pending wider application of the method in our own hands and those of others. No complications, disability, or recurrence to date has occurred—admittedly a promising beginning.

The economic status of the patient is an important factor in the choice of therapy. Inability to face the expense and time loss involved in surgical treatment of hydrocele may counterbalance the inconvenience of a series of injection treatments over a period of time. In charity hospitals, where beds

are at a premium, injection therapy is an invaluable therapeutic aid in the outpatient department.

The simplicity of the method may prove its worst enemy, for its indiscriminate use by those inexperienced in its technique or unable to recognize scrotal pathology will only bring discredit to a procedure which time and experience may prove to be a method of choice. The best test of any procedure lies in whether one would subject himself to the same method if he had such a condition. For myself, I would certainly have a hydrocele injected before choosing open surgery.

Sincere thanks are extended to Dr. Clarence G. Bandler for his sponsorship of this work and the privilege of making this report.

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# DIRECT AND INDIRECT HERNIA IN THE LIGHT OF THE NEWER INTERPRETATION OF THE ANATOMY OF THE ANTERIOR ABDOMINAL WALL\*

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IN a former contribution, the following concepts were advanced in reference to the inguinal region:

1. The primary cause of hernia is the so-called opening through which the viscus appears, and not the viscus per se. The opening should not be considered as a defect nor fault in the body wall, but rather as a definite well-planned exit for structures, which through evolutionary changes have been found to be most advantageously maintained outside the abdominal cavity.

2. In a comparison of the inguinal canal with the many diverse valvular constructions found elsewhere in the body, one is impressed with the singleness of pattern or uniform mechanism employed, a fact which heretofore has not been sufficiently stressed in the literature. The mechanism is the oblique projection of the structure to be constricted through two or more layers of muscle, the valve effect or constriction being obtained from the muscle tone or by muscle contraction. This may be considered as a universal scheme of valve construction.

3. The average pattern of the inguinal region, or the lateral division of the abdominal wall, is directly dependent upon the development, which may be considered as having two factors: (a) the development of the abdominal plate; and (b) the development of the funiculus. The insertion of the gubernaculum cord, i.e., the funiculus non-growth factor, in the undifferentiated abdominal wall and the subsequent development about it of three parallel muscles, two active and one passive, give evidence

of such a valvular construction. These three muscles by their fan-like insertion, slide action and contraction, normally close the triangular space bounded by the ilium, pubis and the Poupart line. Little importance is placed in the pressure resisting action of the external oblique muscle, which because of its fixation and early canalization plays only a passive rôle in the resistance to intra-abdominal pressure.

4. Conceiving nature as continually experimenting (or as some call the process, evolving), one naturally comes to the thought that this evolution process causes changes, i.e., variations in the primary pattern of valve construction. These changes of variation, however slight they may be, will influence (a) the definite pattern, (b) the size, shape, and tension of exits, and (c) will produce widened, narrowed, and attenuated conditions of the transversalis and internal oblique muscles, the structures producing the exits. The depicted variations are due to excessive pull or recession of these muscles from the Poupart line. Such modifications result in a greater than ordinary triangular space between the ilium, pubis, and Poupart line, and leave the space unprotected to a greater or lesser degree from the intra-abdominal pressure, thus enhancing the potentiality for hernia, i.e., the protrusion of a viscus.

In my earlier paper I stated that the important problem is to determine whether inguinal hernia, direct and indirect, occurs more frequently in the cases in which the triangular space bounded by the ilium, pubis and the Poupart line is largely unprotected. At the outset of the present

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investigation it was realized that this problem and the concepts of my former contribution are but a division of a greater problem—the consideration of the entire anterior abdominal wall, especially that part which is infra-umbilical. This has to do with the divisions of the abdominal wall; the average pattern, and the effect of the variations on the potentiality for hernia. Of further importance is the question, what rôle, if any, does the reciprocal compensatory interplay of the divisions of the anterior abdominal musculature play in the prevention of hernia?

For purpose of analysis the anterior abdominal wall may be divided into two parts: a *medial*, bounded by the linea semilunaris and ventral midline, the lower rib margin, and the pubic bone; and a *lateral*, bounded by the linea semilunaris and the dorsal flank, the lower rib margin, and the ilium and pubis. For the purpose of description the anterior abdominal wall may be considered under three heads: (a) the development of the mesenchymal, blastemal or myotomal plate; (b) the development of the gubernaculum cord and the spermatic funiculus; and (c) the development of the rectus abdominis muscle cylinder.

The anterior abdominal wall begins as a ventral extension of the thoracic myotomes that fuse into an undifferentiated mesenchymal or blastemal plate, in which are developed the ribs (seen in embryos of 5 to 7 mm.). The rib rudiments seemingly divide the plate (which is lined within by undifferentiated endoabdominal fascia and peritoneum, and without by undifferentiated external body fascia) and skin into two tangentially splitting sheets—a *lateral* (which differentiates into the posterior serrati muscles and external oblique muscle), and a *medial*, which extends between the ribs and medial to them, forming the intercostal muscles, the internal oblique and transversalis muscles (seen in embryos of 14 mm., 7 to 8 weeks). The external oblique, internal oblique and transversus

muscles become parallel and superimposed and extend ventrad to the midline, caudad to the upward progressing coxal blastema and the blastemal inguinal ligament, being guided to contact by the ventral curving of the ribs and the formation of the sternum. Toward the eighth or ninth week (18.5 to 20 mm. embryo), the symphysis pubis is formed (at first composed of blastemal tissue, in which tissue, first hyaline, then fibrocartilage, becomes differentiated).

After completion of contact by the downgrowing abdominal plate with the coxal bone and the inguinal ligament, the true pelvis is brought into the upright position from the horizontal forward position, by the enlargement of its sagittal diameter, causing the frontal-facing pubic crest to rotate to its definite position, which is superior and posterior. The dimensions of the differentiating mesenchymal abdominal plate then are from the flank to the ventral midline, and from the lower costal rim above to the ilium-pubis and the symphysis below. An intensification of growth occurs at this time (8 to 9 week, 20 mm. embryo). This growth episode in the musculature of the abdominal plate causes a pull or stress in three directions, sagittal, longitudinal and coronal. As a result of this tridirectional growth and stress, the abdominal muscle plate, which is being tangentially split into three superimposed muscles, undergoes transformation or degeneration into fasciae and aponeuroses, at areas of maximum tension, causing a recession of the muscle fibers along the inguinal ligament, pubic bone, and midline, which are the areas of maximum tension. Because of this transformation or degeneration, only the fascial coverings of the muscles remain in these regions and there are formed areas of muscular deficiency, the size of which depends upon the intensity of the pull or stress and the amount of degeneration. These areas have heretofore been considered defects in the abdominal wall. Since the line of muscle tension is 90 degrees it will cause the areas of muscular deficiency to be semicircular in shape, and cause the forma-

tion of arch pillars or points of retention. The arch spans are (1) ventromedial arch, linea semilunaris (condensation of the

aid in the closure by their own contraction and their increase in diameter.

In this seemingly solid tangentially

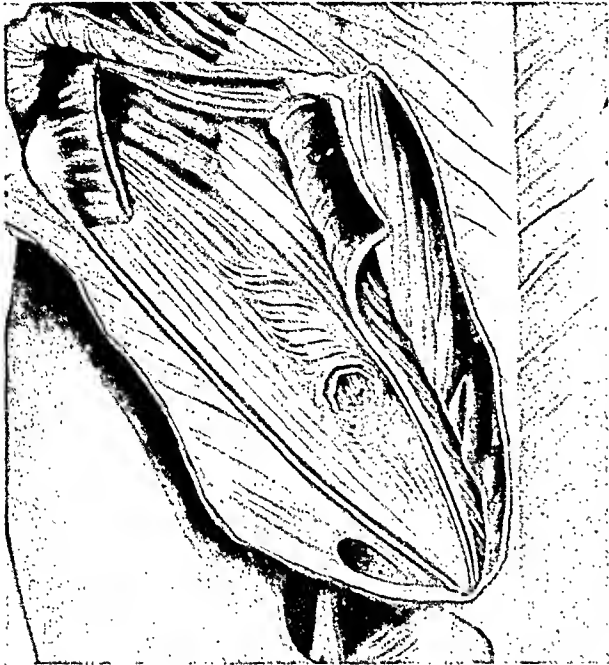


FIG. 1. Transversus abdominis muscle is fascial. Internal oblique, while high arching, is fleshy. Conjoined tendon is long but of good quality. No hernia present, but a potential type.



FIG. 2. Transversus abdominis muscle is fleshy with cephalic recession above the anterior superior spine. Internal oblique is of average pattern and fascial. Conjoined tendon consists mainly of transversalis component. A potential hernial type.

external and internal oblique and transversalis muscles), from the costal cage to the pubic bone as the lateral margin of the sheath of the diameter increasing rectus abdominis cylinder; (2) inguinal arch from the pubic bone to the inguinal ligament, as the fibers of the transversalis and internal oblique muscles; (3) arch of Douglas, from the pubic bone to the symphysis, as the arching fibers of the transversalis muscle.

There is formed by the union of a pillar from each of the three arches of this multiple arch formation a common pillar of retention or insertion into the pubic bone, the conjoined tendon. The anterior abdominal wall acts as a contraction mechanism, about the inserted structures, i.e., rectus abdominal muscle cylinder and gubernaculum cord found in the above described areas of muscular deficiency, and effectually closes the areas, provided that all essential structures of the abdominal wall adhere to the primary pattern and no variants develop. The inserted structures

laminated plate of fused myotomal tissue, extending from the dorsal thorax to the ventral midline and from the lower rib margin to the ilio-inguinal ligament and the pubic bone, two special structures appear, even before differentiation of the myotomal mass. *First*, the gubernaculum, lateral in position and at right angles to the inguinal ligament and the muscle plate or sheets, and *second* the rectus abdominis cylinder. The gubernaculum cord, consisting of a group of special muscle cells arranged into a cylindric mass, joins the inguinal crest and the testicular ligament on the inside and the scrotal ligament and skin on the outside to become a completed structure, the gubernaculum testis. In the differentiation of the abdominal plate, the two inner muscles, internal oblique and transversalis seem to enfold the gubernaculum cord, while the third or external oblique becomes evaginated for its exit.

The longitudinal growth of the body causes the muscle fibers of the internal oblique and transversalis to be seemingly pulled from the Poupart ligament into a

muscles, i.e., the internal oblique and transversalis in the triangular arch space bounded by the ilium-pubis and Poupart line.

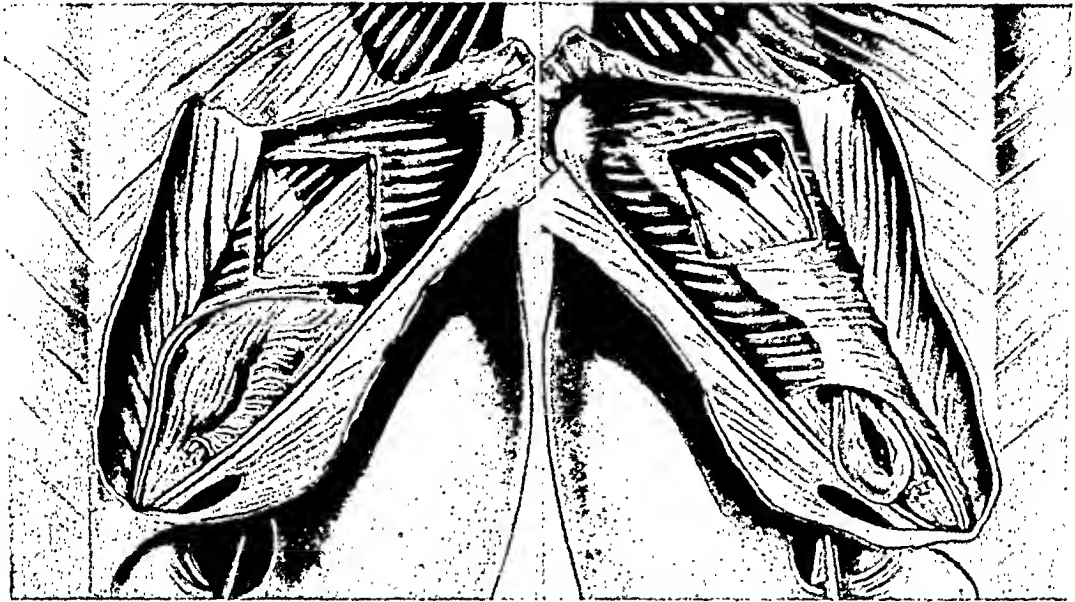


FIG. 3. Variation of the transversus muscle with poor compensation of the internal oblique. Result—a direct hernia.

FIG. 4. An indirect hernia due to fascial degeneration of transversus and internal oblique muscles. Conjoint tendon components are completely fascial.

fan-like movement, resulting in the attenuated fascias of the internal oblique and transversalis muscles. This process is accomplished by muscle growth and the growth of the ilium; as a result, therefore, of the cephalic movement only the fascial covering of the internal oblique and transversalis muscles remains. This results in an area of muscle deficiency bounded by the ilium-pubis and Poupart line, the size of which depends upon the amount of recession of the muscle fibers. Thus is formed what is considered by some a defect but in reality is a point of exit for the testicle. Because the gubernaculum cord has no cephalic growth, the testicle is apparently pulled down, but in reality it is guided into the evaginating attenuated fibers and fascias of the internal oblique and transversalis muscles, retaining them as coverings. These coverings are collectively called the cremaster body. When development is complete, the funiculus acts as a substitute for the pressure-resisting

At about the sixth week (7 to 9 mm. embryo) while the abdominal plate or sheet is still indefinitely laminated into three superimposed muscles, there differentiates in the advancing edge of the myotomal plate (the myotomal lateroventral down-growth) a group of special muscle cells that are arranged at right angles to the axis of the growth, and form a cylindric mass, the rectus abdominis rudiment. The above cylindric mass of tissue is formed from the components of both the *medial* sheet (that differentiates into the intercostals, internal oblique and transversalis muscles), and the *lateral* sheet (that differentiates into the external oblique and the posterior serrati muscles), but mainly from the medial sheet. It causes to be formed about it an oval cylindric tube or condensation of tissue or sheath which is derived from both sheets of the myotomal plate. The lateral line of demarcation of the sheath is called the linea semilunaris. The rectus rudiment, there-



fore, extends from the outer fascial limitation of the mesenchymal plate (the ecto- or external abdominal fascia) above, to the

gubernaculum cord and its definitive funiculus spermaticus.

We may now visualize an average

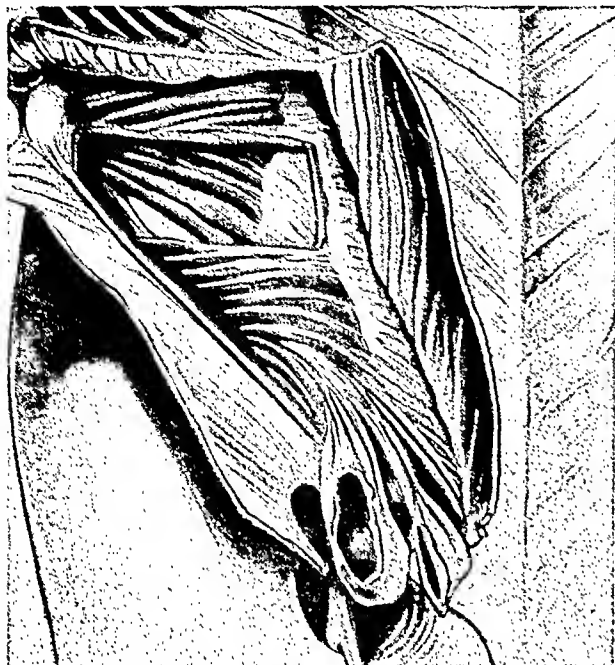


FIG. 5. Transversus and internal oblique muscles apparently show an average pattern, but are really variations of marked degree in that their fibers split, causing condition of marked recession and hernia potentiality and formation. The conjoint tendon is fascial, showing degeneration of the medial aspect of the muscles with poor resistance to intra-abdominal pressure. Result—hernia.

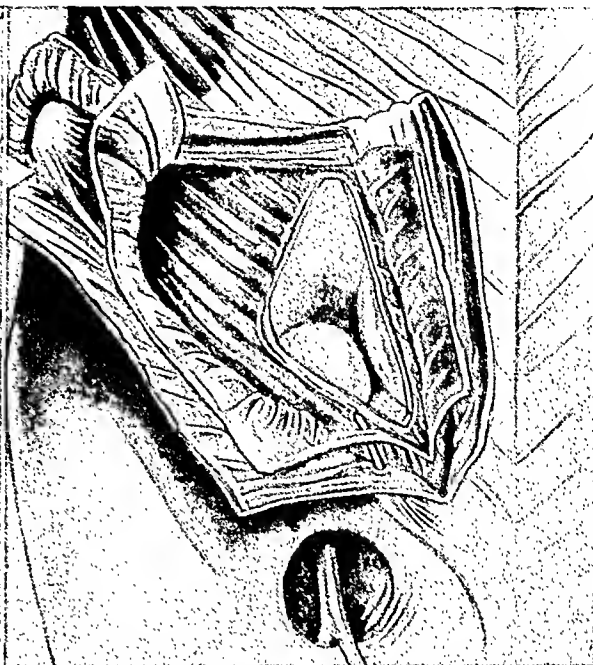


FIG. 6. A right undescended testicle. Obstruction caused by no arch formation of the lateral component.

inner fascial limitation (the endo-abdominal fascia), below.

As and when (seen in a 14 mm. 7 or 8 week embryo) the curving lateroventral downgrowth makes contact with the coxal bone, the ventromedial part containing the rectus abdominis rudiment, makes contact with the boundary of the true pelvis at the pubic rudiment—the pubic rudiment having been brought into the upright position from the horizontal forward position by the enlargement of the sagittal diameter of the true pelvis. After the rectus abdominis rudiment makes contact with the pubis, it extends from the anterior rib aspect, beneath the anterior limitation of the lateral sheet, the ectofascia, to the pubic crest insertion and posterior aspect or limitation of the medial sheet, the endofascia, and is enveloped by the internal oblique and transversalis muscles, as is the

pattern of the anterior abdominal wall. It is a flat, musculofascial structure consisting of two major divisions, a medial division and a lateral division united by a curved fascial condensation or reënfacement, the linea semilunaris or ventral arch, which is the lateral demarcation of the rectus abdominis sheath, and extends from the costal margin to the lateral aspect of the pubic bone.

Each of the divisions is partly muscular and partly fascial or aponeurotic. In the caudal part of each is found an arch of muscle or aponeurotic fibers, the inguinal arch (internal oblique and transversalis muscles), and the semilunar arch of Douglas (transversalis muscle), respectively, from the concave edge of which there is prolonged to the attachment on the coxal bone attenuated fasciae, the result of transformation or degeneration of the laminated superimposed muscles. The medial pillars of these two arches fuse with the caudal extremity of the fascial reënfacement, the linea semilunaris, to form



a structure of insertion into the lateral part of the pubic bone, the conjoined tendon. The lateral pillars of the arches are inserted, respectively, into the ilium pubic line (inguinal ligament) and the symphysis pubis. A bridge of muscle and fascia extending from the ilium (anterior superior spine) to the midline (symphysis pubis) and buttressed by a medial pier of support, the conjoined tendon, is the result; and as a bridge construction reacts to stress, so, too, the entire abdominal wall and not only any one part or division of it will react to intra-abdominal pressure.

The mechanics of bridge construction make evident the compensatory action of parts of the abdominal wall under pressure, and as a corollary there follows this fact, that the shorter the distance from pillar to pillar of an arch or series of arches, the greater the strength found in the bridge construction and the more resistance it has to strain. When the arches and the areas of muscular deficiency are of average pattern and no variants develop in the wall, the insertions of the gubernaculum cord or the definitive funiculus spermaticus and the rectus abdominis muscle, about which the arch formations contract, are accessory factors and are of but secondary importance in the resistance to intra-abdominal pressure. We are also brought to the thought, that as a bridge consists of many parts or members, not all of which are of equal tensile strength, the ability to stand strain, even excessive strain, without failure is due largely to the compensatory shift or stretching that occurs under stress; so too, in the mechanics of the abdominal wall there is a compensatory action of parts of the abdominal wall, and even when there is excessive stress upon a greatly strained area, complete failure of resistance to the intra-abdominal pressure or hernia, i.e., viscus protrusion, is prevented.

In the former study the transversalis muscle was considered and variations depicted. In this study, comparative in nature, it was found that while the abdominal wall acts as a whole in the average

pattern, variations are found in each component of the abdominal wall. These variations influence the coördination of its component parts and its potentiality for hernia. The reasons for the small number of hernias generally found where the areas of muscular deficiency of the abdominal wall are greater than average, is the ability of one part to compensate for another.

In a detailed study of variations of the abdominal wall, it becomes necessary to consider each individual component, and to analyze its effect in minimizing or aggravating the potentiality for inguinal hernia, direct and indirect. Accordingly, I shall describe the average pattern and thereafter the variational types.

The fibers of the transversus abdominis and internal oblique muscles that hug the cord snugly are arched from the medial one-third to one-half of Poupart's ligament to the lateral aspect of the pubic bone. The muscle fibers having degenerated or transformed or receded synchronously and equally, the tilting of the pelvis causes a seeming difference in elevation. In the variations may be found recessions of all degrees, from absence of recession (where due to defective tension lines the muscle fibers fail to recede from Poupart's ligament or to form an arch), to recessions measuring  $1\frac{1}{2}$  inches above the anterior superior spine. Such variations of the arching fibers are found in both muscles, the internal oblique and the transversus, being frequently present as a variant in one, with an average pattern in the other.

While excessive recession of the muscle fibers and the production of areas of attenuated fasciae of greater than average size, at the sites of maximal tension, is frequent, the opposite condition, i.e., absence of recession, is not infrequent; the latter being due either to faulty angles of tension or to total absence of the amount of pull or stress which is required to produce an average pattern of the anterior abdominal wall. As a result the muscle fibers do not recede from the coxal bone; form no arches or bridge of muscle fibers

and no areas of attenuated fasciae. Absence of recession or arch formation indicates an arrest of development at the seventh or eighth week (the 14 mm. stage), and since it is at this time that the change in position of the testicle known as the descent of the testis begins, any arrest in the development of the abdominal muscle plate will influence this mechanism. Due to the arrest in development of the muscle plate the gubernaculum cord, while present, is prevented from functioning, and the larger testicle meets resistance at the inner aspect of the abdominal wall and finds its exit through the wall and into the scrotum blocked. The cases of delayed descent may be explained by a late or tardy recession of the fibers from the coxal bone at the time of puberty, at which time there occurs a marked longitudinal growth episode.

The conjoined tendon is usually described as those parts of the internal oblique and transversalis muscles which unite to insert simultaneously into the pubic bone (crest and tubercle) in front of the rectus abdominis muscle. There is no fault to be found with the first part of the above description, but we cannot, in view of the foregoing, consider the conjoined tendon as a simple simultaneous union for insertion. It is rather the middle pier of the anterior abdominal wall with a definite construction the purpose of which is resistance to intra-abdominal pressure. Variations indicate that its types are long, short, widened and attenuated. These types may also be considered as indices to the variations of the laminated muscles with which they are continuous. Therefore, the conjoined tendon is found to be completely muscular or completely fascio-aponeurotic, depending upon whether the muscles adhere to the average pattern or are variants.

The rectus abdominis muscle being a simultaneously developed structure will be affected by the same growth mechanism as is the abdominal wall and will, therefore, show the same types of variation. The lower part due to strain will be muscular or

fascial to a greater or lesser degree depending upon the stress put upon its musculature after completion of contact with the pubic bone. Thus we find short, bulky, muscular and long, attenuated, tendinous insertions of the rectus abdominis muscle. These insertions, located in areas of attenuation of the anterior abdominal wall that are greater than average, will influence the potentiality for hernia in direct proportion to the amount of muscle, or fascial content found in the insertions. The more muscle, the greater the ability to contract and increase the diameter of the rectus, the greater the ability to aid in the protective mechanism required to resist intra-abdominal pressure.

#### SUMMARY

1. A detailed study and a completed picture is drawn from the available embryologic data describing the anterior abdominal wall.
2. The average and variational types of the component parts of the abdominal wall are detailed and depicted, and their effect upon potentiality for hernia analyzed.
3. There are advanced:
  - (a) An explanation of the mechanism of formation of the linea semilunaris.
  - (b) A reason for the belief that one of the causes of non-descent of the testicle is mechanical obstruction.
  - (c) A concept of the anterior abdominal wall as a bridge construction of multiple arches, the mechanism and function considered as potential factors in the causation of hernia.
  - (d) A concept of the conjoined tendon as the middle pier of support of the anterior abdominal wall.
  - (e) A reason why more hernias do not occur when the area of muscle deficiency is largely increased from the average.

- (f) An explanation of reciprocal compensatory action of the entire abdominal wall as a preventive of hernia.

#### CONCLUSIONS

1. Complete failure of the abdominal wall in its resistance to intraabdominal pressure and hernia formation is improbable, if not impossible, when an average pattern is present.

2. Hernia formation may occur as a structural and functional failure of the entire abdominal wall or of any part or division due to:

(a) Deficiency in the musculature of the component parts of the abdominal wall, the result of extreme degeneration or transformation into fasciae or aponeuroses, which have little ability to resist pressure.

(b) Variations in the component parts of the abdominal wall of such degree that complete valvular closure even with maximum contraction is impossible.

(c) The occurrence of simultaneous variations in two or more components of the wall.

(d) Delayed or non-coordinated action of the components of the abdominal wall, resulting in a failure of compensation and a deficient valvular mechanism.

This paper has as its purpose an attempt to clarify some of the basic factors that underlie the production of hernias, direct and indirect, and the causes of postoperative recurrences of direct and indirect hernias. The phases studied and detailed have been those of the variations from the average pattern.

I wish to extend thanks to Dr. J. Parsons Schaeffer, Director of the Daniel Baugh Institute of Anatomy of the Jefferson Medical College, for his interest in this study and for the access to the anatomic material, and also to Dr. N. A. Michels for his helpful suggestions in the preparation of this paper.

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# TEN YEARS' EXPERIENCE WITH LEG ULCERS IN THE OLD AGE GROUP\*

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WE present a statistical review of leg ulcers based upon the material of the last ten years at the Neurological Hospital. The number of these cases was so great that this division of the surgical wards could be distinguished with ease by the olfactory sense. As a result, these cases were in favor with neither the physicians nor the nurses. Each patient was furnished with a pail containing hot water and soap, some ointment and bandages—he treated himself! Only in the Home† were the patients “doctored.” An inmate and former sailor had opened his “office” behind the firehouse in a shack where he conducted a well frequented “clinic.”

The surgical department started its work by eliminating this eyesore. An ulcer program was organized on a scientific basis. Consequently, the once familiar scene of the aforementioned privileged patient holding his “clinic” in full “septic” sway, was no more. We organized an ulcer service from the scrap, assigning the member of the surgical staff most experienced along these lines to the care of the cases. This practice has been continued up to the present time.

By frequent consultations and reexaminations, interest in these cases has been

† The Home is the city almshouse of approximately 1,700 inmates, who when medical care or hospitalization is required are transferred to the adjoining Neurological Hospital. These institutions are located on Welfare Island, New York City.

kept awake and abreast of modern scientific developments. To the old and approved method of compression bandages which we have used routinely, new therapeutic measures are continually being added to our armamentarium. This selection is being made according to sound surgical principles out of an abundance of methods which in themselves sometimes pay no attention to surgical principles and herald methods as new, which in reality were generally adopted for more than half a century. For this reason, we consider it appropriate not to restrict ourselves to mere figures and statistics, but also to present a brief clinical picture of our cases including treatment and diagnosis in general.

Our statistics cover the period from January, 1927 to December, 1937. During this decade, we discharged from the hospital 134 cases of leg ulcers. The records of all these cases were carefully studied and included the nurses' notes for completeness.

Classification of the cases according to treatment proved impossible. Whereas ace and elastoplast bandages or Unna boots were used routinely in all cases, the additional auxilliary treatment was selected not only for each case individually, but also modified and adapted in each case to the changing condition of the ulcers as well as to new drugs and the new means that scientific research was offering at the time. Therefore, in addition to the pressure

\* The material in this article was submitted as part of a symposium on leg ulcers presented at the Neurological Hospital January 6, 1938. Included discussions were Anatomy, Physiology and Etiology by Dr. B. A. Goodman and Special Technique by Dr. H. J. Philipp.

bandage, a variety of treatments has been used. This point is illustrated in the following cases:

Mr. J. K., 80 years old when discharged, had been treated in the hospital for five years for an extensive ulcer with ace bandages, Unna boots, numerous ointments, insulin dressings, diathermy, histamine injections to improve arterial circulation, x-ray, and curetting of the ulcer.

Another patient with a large ulcer was turned over to the physiotherapy department for histamine iontophoresis. Later he was found to have sarcomatous degeneration of the ulcer which necessitated amputation.

C. G., 63 years old, had an extensive ulcer which required skin grafting as an auxiliary means after the development of sufficient granulations.

The cases cited demonstrate the necessity for surgical supervision and follow-up as well as the impossibility of classifying our material according to treatment.

Pathologic classification is more feasible with our material and will be outlined subsequently. Before discussing the statistics we present a general view of our material.

There were 134 cases treated in all over the full period from 1929 through 1936. Of these only nine were below the age of 50, while the vast majority were over 60 years of age. The age distribution is shown in the following table:

	Number	Per Cent
Below 50.....	9	7
50-60 years.....	32	24.8
60-70 years.....	47	36.5
70-80 years.....	35	27.1
Over 80.....	6	4.7
Unknown.....	5	
Total.....	134	100.0

The largest group of patients is that between 60 and 70 years of age, the smallest the group over 80.

In patients of this age group it is to be expected that concomitant diseases would be of frequent incidence. Syphilis, heart dis-

ease and arteriosclerosis were the most frequent contributory disease factors. Cardiac conditions, particularly chronic myocarditis and valvular disease, were diagnosed in not less than seventy-four cases (55.2 per cent), and general arteriosclerosis in almost as many. It is our opinion that the figure for arteriosclerosis might well be corrected, since probably 65 per cent of the patients suffered with it. Among these arteriosclerotics, every tenth patient developed gangrene of the affected leg and every twelfth patient a cerebral hemorrhage. In thirty-five cases arteriosclerosis and heart disease were associated, and this group showed the highest mortality.

TABLE I  
CONCOMITANT AND CONTRIBUTORY DISEASES

	Number	Per Cent	Per Cent Mortality
Syphilis.....	11	8.2	
Cardiac.....	74	55.2	43.2
Arteriosclerosis.....	60	44.8	33.3
Cardiac plus arteriosclerosis.....	35	26.1	48.5

The mortality rate in general proved rather appalling: forty-four of the total number—every third patient—figured in

TABLE II  
RESULTS OF TREATMENT

	Total Number of Cases (134)		Completely Treated Cases (93)	
	Number	Per Cent	Number	Per Cent
Completely healed.....	38	28.0	38	40.0
Almost healed.....	29	21.6	23	24.7
Greatly improved.....	35	26.1	23	24.7
Improved.....	12	9.7	6	6.4
Not improved.....	20	15.0	3	3.2

the mortality statistics. However, it must be emphasized that the age group was very high and that in no case had the cause of death any connection with the leg ulcer.

The death rate of the cardiac-arteriosclerotic group was higher than the general average.

For the entire group of 134 cases, the results of treatment are given in Table II. They show that good results were obtained in almost half the cases, and some improvement in 85 per cent. In the ninety-three cases in which treatment could be carried through to its conclusion, the results were much better: good results in 64.7 per cent and improvement in 96.8 per cent.

The effects of treatment as related to concomitant diseases is shown in Table III, both for the entire group and for those cases in which treatment was completed.

TABLE III  
RESULTS OF TREATMENT

	Cardiac (74)	Com- pletely Treated (45)	Arterio- sclerosis (60)	Com- pletely Treated (41)	Syphilis (11)
Completely healed...	24.3*	40.0	28.4	41.5	
Almost healed.....	20.2	24.4	23.3	22.0	18.1
Greatly improved...	25.6	26.6	21.6	24.3	45.5
Improved.....	14.8	6.6	11.6	7.3	27.2
Not improved.....	14.8	2.2	15.0	5.0	9.0
Died.....	43.2	....	33.3	....	27.2

\* All figures on percentages.

If the facts presented regarding the age, contributory diseases and death rate of our series are pictured collectively, we have, to the best of our knowledge, an unparalleled group of cases yet to be published. A pessimistic attitude regarding the curability of any one case is readily understandable.

In the cases complicated by syphilis, eleven in all, none was completely healed; 18.1 per cent were "almost healed" on discharge; 45.5 per cent were greatly improved; 27.2 per cent were somewhat improved, and 9 per cent were not improved. The cardiac group was the largest, seventy-four cases. Of these, 24.3 per cent were discharged "completely healed," and 20.2 per cent "almost healed." "Good results" represent 45.5 per cent of the cardiac cases. The arteriosclerotic group, slightly smaller than the cardiac, with sixty cases, showed 28.4 per cent "completely cured"; 23.3 per cent "almost

healed," that is, "good results" in 51.6 per cent of the cases. The failures are almost identical with the fatalities. The death rate among the arteriosclerotic failures was 80 per cent; among the respective cardiac group 90 per cent.

In no case in the whole series had death been caused by the ulcer. In fact, the ulcer in a great number of the patients was only an accidental finding. We therefore feel that our results are distorted, and that it would be fair to include in our statistics an evaluation of the cases in which we had the opportunity to carry out the treatment for a reasonable length of time. Among forty-five cardiac cases in which treatment was carried through, 40 per cent were discharged "completely healed"; 24.4 per cent "almost healed" or 64.4 per cent with "good results." Among the forty-one arteriosclerotic cases, 41 per cent were discharged "completely healed," 22 per cent "almost healed"—i.e., "good results" in 63.5 per cent of the cases.

The excellent results obtained have considerably altered the aspect of our wards. Whereas formerly leg ulcers belonged to the category of common diseases, there are no more than six cases in the hospital at present and about thirty cases in the Home (all of them ambulatory).

The varicose type of ulcer has predominated, although the arteriosclerotic type is also very common. Several syphilitic and occasional neoplastic ulcers have been seen. Other types include the trophic, infectious, tuberculous, traumatic, epidermophytotic, actinomycotic, and ulcers due to other granulomata.

Etiologically, the one outstanding factor is that the great majority of leg ulcers (93 per cent) occur after the age of 50. Pathologically it is evident that they are frequently associated with arteriosclerosis of the vessels of the legs. (Fig. 1.) This latter relationship is of considerable importance, since we have been impressed with the frequent finding of arteriosclerotic changes in the vessels of the lower extremities in autopsies of patients who had

chronic leg ulcers. Occasionally the arterial changes are found to be much further advanced than the changes in the veins.

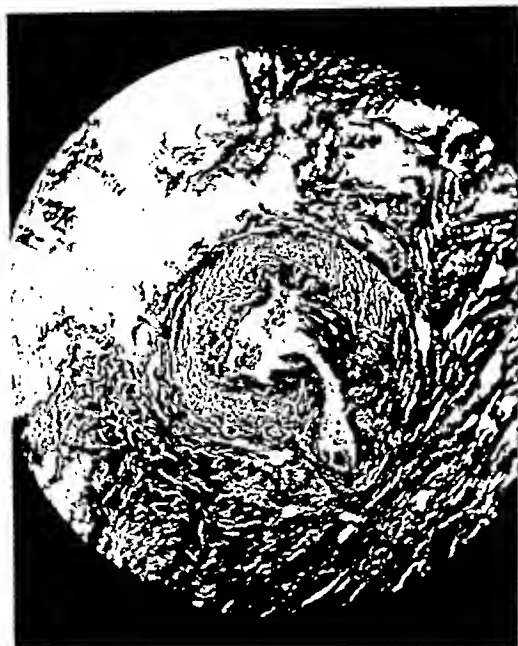


FIG. 1. Small artery at the periphery of an ulcer with marked arteriosclerotic changes.

The varicose ulcer is essentially a chronic ulcer. Its chronicity may be maintained by several factors: (1) chronic irritation; (2) infection; (3) poor nutrition, including trophic disturbances; and (4) circulatory insufficiency. All these factors may, and frequently do, occur simultaneously. But the determining cause in most cases is eventually a circulatory one, for in the presence of an ample circulation the other causes may be obviated.

Due to pressure from above, or from the force of gravity exerted after prolonged standing, the deep veins lose their competency. As a result, the blood, instead of flowing from the superficial veins into the deep ones, at times flows in the reverse direction. Stagnation of the blood in the superficial veins occurs, and is followed by a general retardation of the blood stream, so that finally the walls of the veins themselves receive insufficient circulation for their needs. These walls weaken, and fluid begins to exude from them into the neighboring tissues. Because of the intense

congestion, some of the small veins rupture, discharging their contents into the tissue spaces. Some of this blood is absorbed, but part of it remains as blood pigment. (Fig. 2.) Due to the presence of the latter as well as to the occurrence of occasional trauma and infection, an inflammatory process is set up. Healing takes place slowly with resultant connective tissue deposition which in contraction causes obstruction of the small blood vessels and lymphatics. Obstruction in the latter causes further edema in the tissues, while obstruction of the former results in poor nutrition and further tendency to ulceration.

Thus a vicious cycle is established. The small arterioles are continually disturbed due to accumulation of cells in the inflammatory process and become sclerosed or thrombosed. The venules remain dilated. The surrounding tissue is edematous. Ulcers come and go. At first the epithelium is able to regenerate and cover the healing ulcer, but as the process continues and the blood supply of the arterioles is diminished, regeneration becomes impossible. If now the larger arterial trunks have become arteriosclerotic, the chronicity of the ulcer is established. Whatever healing does take place, occurs by fibrosis after the superficial tissue has been sloughed.

Particular emphasis must be laid on the scarring process which may be extensive enough to involve all the tissues in the vicinity of the ulcer, extending as far down as the periosteum of the bone. Although this fibrosis is a step in repair it may act as a deterrent to complete healing. When it occurs in the depths of the ulcer, the edges are tied down, and in addition, the fibrosis itself is apt to become hyalinized or calcified. (Fig. 3.) Accordingly, the varicose ulcer depends for its continuance not on the venous factor alone, but more particularly on the arterial and lymphatic as well. It should, therefore, be considered as a circulatory ulcer, rather than one merely due to varicose veins. These factors must be considered in therapy. If treatment is to succeed, it must be instituted and main-



tained before extensive fibrosis and scarring have occurred.

More than one etiologic factor may play

ulcers are often multiple and tend to be located chiefly on the outer aspect of the upper part of the leg.



FIG. 2. Dilatation of venules; increase of tissue spaces; cellular accommodation; extensive deposition of pigment.

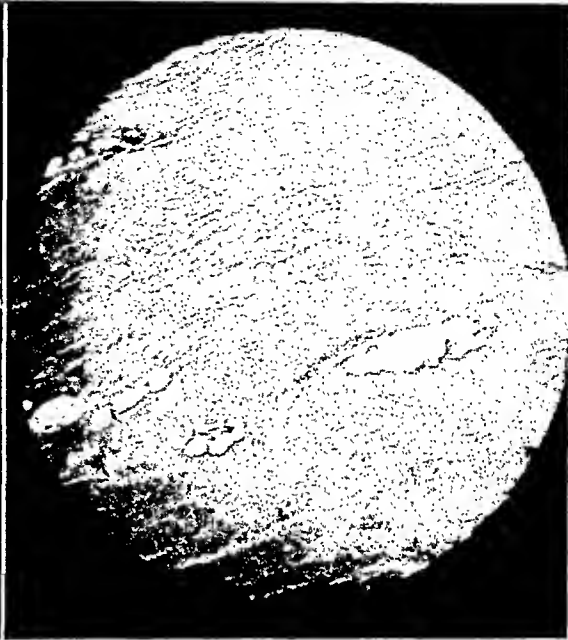


FIG. 3. Fibrosis and scarring in wall of chronic ulcer.

a part in ulcer formation. For example, the simultaneous presence of varicosities and arteriosclerosis is common in our material; also syphilis with varicosities; and other combinations.

The diagnosis is not always easy. When varicose veins are the cause, we look for the following signs and symptoms—visibility of enlarged palpable veins which disappear or decrease in size on elevation of the extremity, edema on standing and the Trendelenburg, Perthés, and percussion tests.

The diagnosis of arteriosclerotic ulcer depends on the determination of the degree of arterial incompetency. The diagnostic methods include the Buerger postural test, pulses in the foot, color changes, symptoms of pain and claudication, x-ray to reveal calcification of the arterial walls, occasional arteriograms, routine oscillometry and temperature changes.

The luetic ulcer gives a definite history of infection and positive serology; the ulcer is covered with a firm grayish slough and the edges are raised and indurated, the margins punched-out in appearance. Such

The neoplastic ulcer may be primary or superimposed on the chronic varicose ulcer. We recently treated an unusual case of sarcomatous degeneration on a varicose ulcer. A thorough search of the world's literature revealed only two cases with this pathology. In malignancy, induration is always present and the appearance of the exuberant granulations is characteristic. As in the case of tuberculosis, biopsy establishes the diagnosis.

The tuberculous ulcer is commonly located in the vicinity of joints. It has a soft base and a grayish slough.

In all cases of leg ulcer a routine examination is made and a chart (Fig. 4) made up. In this way etiologic and contributory factors can be considered.

The basic principle underlying the treatment of leg ulcers is support to the circulation. In other words, we treat the circulation and not the ulcer directly. Local treatment is merely an adjuvant measure. The following therapeutic procedures have been used during the past ten years:

*Local Measures.* 10 per cent ichthyol; 1 per cent silver nitrate ointment; cod liver



oil ointment; balsam of Peru; zinc oxide; scarlet red; combined balsam of Peru, vaseline and lanolin; gentian violet; horse

We came to the conclusion that none of these local measures which we had under observation had any special virtue and that

<u>PERIPHERAL VASCULAR CHART</u>			
NAME-	OCCUPATION-	NATIONALITY-	
SEX-	B.P.-		
TOBACCO-	WASS-	ARTERIOSCLEROSIS-	
TESTS:			
1. LANDIS (HOT WATER IMMERSION 110° F.-20 MINUTES).			
	<u>RIGHT FOOT</u>	<u>LEFT FOOT</u>	<u>ROOM TEMP.</u>
CONTROL-	°F	°F	°F
HANDS -	°F	°F	°F
2. OSCILLOMETRY-			
THIGH-	UPPER 1/3 LEG-	LOWER 1/3 LEG-	
3. PULSATIONS-			
DORSALIS PEDIS-	POSTERIOR TIBIAL-	POPLITEAL-	
4. SKIN TEMPERATURE-			
BASE OF TOES-			
5. POSTURE-			
ELEVATION-	PENDENCY-	LEVEL-	
6. HISTAMINE FLARE-			
SYMPTOMS:			
CLAUDICATION-	BURNING SENSATION IN SOLE OF FOOT-		
PAIN IN BUTTOCK-	TROPHIC: NAILS-		
REST PAIN-	HAIR-		
NUMBNESS-	SKIN CHANGES-		
WEAKNESS OF LIMB-	MIGRATING PHLEBITIS-		
ULCERATION-	GANGRENE-		
EDEMA-			
VARICOSITIES:			
LOCATION-	EDEMA-		
ULCERATION-	TRENDELENBERG TEST-		
TROPHIC CHANGES-	PERTHE TEST-		

FIG. 4.

serum; aristol; insulin injected into margins of ulcer; histamine.

Results with gentian violet were poor, in that the ulcers were often aggravated. Scarlet red was found to be of value only when the ulcer was in the stage of beginning epithelialization; it was found best to alternate it every twenty-four hours with a mild ointment.

they were of only minor value. Our experience with physiotherapy likewise showed that its value was doubtful. The methods employed were ultra-violet, natural exposure to the sun, infra-red, heat, diathermy, and iontophoresis. Incorporated in the latter was histamine and saline. The physiotherapy department experimented with copper iontophoresis with notably

poor results in that the ulcers enlarged in size and depth, with added increase in pain.

In those cases where the inflammation was acute, bed rest and wet applications gave relief. Hypodermic injections of histamine with the purpose of improving the peripheral arterial circulation were of questionable value. However, injections of acetylcholine hypodermically gave better results. Hypertonic intravenous saline, particularly in Buerger's disease and arteriosclerosis, was of definite value.

The operative procedures consisted of skin grafts, especially pinch grafts on ulcers covered with healthy granulations; vein sclerosing injections, ligation of veins, ulcer curettage, incision around the margins of the ulcer, biopsies and amputations.

Bacteriophage treatment consisted of an application of a water proof dressing which allowed the serum to accumulate.

π The methods which gave actual results were the pressure bandage in various forms—ace bandage, Unna paste boot, elastoplast and adhesive. Pressure bandages were not disturbed for two or three weeks. This was a definite saving to the hospital because ordinarily it was necessary to change the dressings daily, and a saving in nursing time taken up by daily washing of dirty ulcers. The economy in avoiding innumerable dressings and bandages over a period of ten years was an economic side of the question which added up to many dollars and cents.

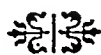
Even in those cases where the odor of the ulcer secretions became objectionable, the pressure bandage was left intact. When necessary, deodorants such as powdered boric acid were applied over the pressure bandage itself.

The pressure bandage is placed over a small soft dressing which covers the ulcer. Thick dressings are avoided since they prevent even pressure. Equalized pressure accounts for a successful pressure bandage, otherwise more harm than good may result. When the secretion is profuse we use the ace bandage; when the ulcer discharge decreases the elastoplast and Unna paste boot are utilized. Before applying the pressure bandage the leg is elevated for one-half hour in order to reduce the edema.

Because of its paramount importance, it must be emphasized again that treatment must have as its prime objective the improvement of the circulation. Any local therapy is only of minor importance.

#### CONCLUSIONS

In the older age group both the venous and arterial systems of the lower extremities are involved. The compression or supportive bandage aids both systems—venous support relieves local anoxemia, etc. The local treatment of the ulcer is only of secondary importance except in those cases where other procedures are warranted by special indications.



# CONCERNING THE SURGICAL PHYSIOLOGY OF DUODENAL ULCER

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THE pylorus forms the distal fixed extremity of the stomach. It lies a little to the right of the midline of the body, opposite the first lumbar vertebra, with the pancreas below and behind and the left lobe of the liver above and in front. The cardia forms the proximal fixed extremity and between these two points the stomach is suspended from the gastrohepatic ligament. The cardiac sphincter guards the entrance and the pyloric sphincter the exit, the former being related to the motor activity of the esophagus and the latter to that of the stomach. The pyloric sphincter is a definite anatomic structure, the best developed of all the sphincters of the gastrointestinal tract, being represented by a local increment of circular muscle fibers about  $\frac{1}{4}$  to  $\frac{1}{2}$  inch in width. During operations under general anesthesia the sphincter is relaxed, making definition difficult, but its location is readily marked by the transverse pyloric veins.

The arteries of the stomach do not reach the pylorus; the latter is supplied from above by the pyloric artery, a branch of the hepatic from which are also derived the branches supplying the first portion of the duodenum.

The anterior and posterior branches of the vagus nerve supply the respective aspects of the stomach but only as far as the pylorus. The latter structure is innervated from above by fibers of the hepatic branch of the vagus which probably also carry sympathetic filaments.

Since the nerve supply of the pyloric sphincter has been the subject of much controversy it may be well to deal with it more fully. Embryologic and comparative anatomic studies cited by Gaskell show that the sphincters of the gastrointestinal

tract have developed from the dermal musculature and at one time formed a continuous muscular investment of the gut. In the course of development most of the dermal musculature disappeared from the gut and that which remained became localized at certain points to form the sphincters.

It is well established that the sympathetic nerves which represent the thoracolumbar outflow of the involuntary nervous system supply motor fibers to all blood vessels and sweat glands, to all unstriated muscle under the skin and to tubular structures derived from the segmented duct. Structures with a common origin usually have a common nerve supply. It has been proved that the motor nerve for the ileocecal sphincter is from the superior mesenteric ganglion. The pyloric sphincter in all likelihood belongs to this group and is supplied by motor nerves from the sympathetic. The vagus, a parasympathetic nerve, supplies inhibitory and dilator fibers to this sphincter and has its ganglion cells located in the wall of the gut. Experimental attempts to localize the nerve supply of the pyloric sphincter have shown conflicting results, probably because of failure to differentiate between sphincter and antral activity as related to the emptying of the stomach, and because of the difficulty of separating vagus from sympathetic fibers. The vagus is not only the motor nerve for the stomach but it is also the inhibitor and dilator nerve for the pyloric sphincter. Cutting it does not disturb the intrinsic mechanism of the stomach which is controlled by local ganglionic cells. The motor activity of the sphincter is under sympathetic control which is nicely correlated with the motor function of the stomach and is also ex-

tremely sensitive to extraneous stimuli not only from the abdomen but from the entire body.

Horton showed by anatomic studies that the musculature of the pyloric sphincter is made up principally of circular fibers whose contraction closes the orifice. He demonstrated also that looped around the circular fibers are muscle bundles prolonged from the longitudinal muscle coat of the stomach. Contraction of these latter fibers which are under vagus control serves to dilate the sphincteric orifice and to hold it open. Thus it becomes apparent that the mechanism of the pyloric sphincter resembles that of the iris of the eye.

The normal function and behavior of the pyloric sphincter have to do with regulating the passage of food from the stomach to the duodenum and probably with the regurgitation of duodenal contents into the stomach. Recent investigations indicate that acidity on the gastric or duodenal side of the pylorus does not normally control the activity of the sphincter. Each advancing peristaltic wave in conjunction with increased tonus of the stomach overcomes the tonus of the pylorus and forces some of the chyme into the duodenum regardless of whether the reaction of the chyme is neutral, acid or alkaline. The pyloric tone normally only keeps the sphincter closed when the pressure on either side is insufficient to overcome it.

Structures which are controlled by the sympathetic nervous system exhibit reactions which are peculiarly responsive to many stimuli. Perspiration and pallor of the skin, involuntary evacuation of the bladder and rectum induced by fright and emotional shock; hyperpiesis resulting from worry and nervous strain and from trauma to an extremity may be cited as results of overstimulation of the sympathetic nervous system. Indeed many of the symptoms of surgical shock may be explained in a similar manner. Postoperative intestinal ileus is not caused by paralysis of the intestine, but is due to a preponderance of sympathetic activity, causing inhibition of

peristalsis and spasm of the sphincters. Spinal anesthesia or severance of the sympathetic nerves promptly relieves or prevents this condition. Mere sudden forcible contraction of the stomach would cause ejection of its contents into the duodenum; therefore, for vomiting to occur there must be coincident closure of the pylorus by contraction of its sphincter and reversal of gastric peristalsis.

All stimuli which affect the sympathetic nervous system do so by causing an increase in the output of the adrenal glands. The action of epinephrine is limited to structures having sympathetic innervation, there being no effect on nerves of the autonomic system. The sphincters are made to contract by sympathetic stimulation and their tone is probably increased by atropine which paralyzes the local inhibitory ganglia.

By application of this general knowledge of sphincters to the pyloric sphincter it is presumably correct to say that normal tonus maintains closure of the pylorus, that it relaxes and opens in response to vagus stimulation as it occurs in gastric peristalsis, and that spasm of the pyloric sphincter occurs from local or reflex irritation.

Surgical diagnosis must frequently differentiate between gastric symptoms caused by intrinsic disease of the stomach and gastric symptoms which are manifestations of extragastric lesions. Ulcer of the stomach or duodenum is a local irritative lesion whose symptoms are directly related to the functional activity of the stomach. The regularity and periodicity of symptoms, especially of duodenal ulcer, are constant from day to day. The stomach often exhibits hypermotility and there is usually spasm or achalasia of the pyloric sphincter. The etiology of duodenal ulcer is as vague as ever. Its experimental reproduction has not simulated the conditions found in the human. Infection seems to play a part but the predisposing factors, especially those which promote chronicity, remain unknown. The fact that duodenal ulcer occurs so often in certain

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individuals of a characteristic habitus described by Draper and Hurst, that it is often found in several members of a family of the same and succeeding generations, that it is often prone to recur after surgical treatment, that it seems to bear some relationship to the use of tobacco (nicotine paralyzes the vagus terminals), and that the symptoms of ulcer are often accentuated by worry or nervous strain are highly significant and suggestive of a nervous influence in etiology.

Reflex spasm of the pylorus may be caused by any abdominal lesion which irritates the peritoneum. It is often a sequel of abdominal operations, and may even arise from the ligation of the sac of an inguinal hernia done under local anesthesia. Spasm from the above causes is usually temporary, sometimes recurrent at irregular intervals and rarely of much significance. Continual clonic spasm produces hypertrophy of the sphincter as seen in early infancy. The etiology of this condition seems to be best explained by overstimulation of the sympathetic fibers to the sphincter. It has been suggested that hyperadrenalism causes the overstimulation. Mere cutting of the sphincter, however, suffices for cure.

Reflex spasm of the pylorus in the absence of duodenal ulcer and other abdominal lesions may give rise to symptoms which often simulate duodenal ulcer and justify operation. Bastianelli speaks of such cases, which he has treated successfully by the Ramstedt operation. Gastroenterostomy in the absence of ulcer does not relieve the symptoms of pylorospasm, but may cause additional symptoms which are only relieved by undoing the anastomosis.

The significant features of duodenal ulcer which may be explained by the activity of the pyloric sphincter are the chronicity and periodicity of symptoms; the unchanging cycle of pain-food-ease-pain; the hypermotility and hyperacidity of the stomach; the selective location of the ulcer in the anterior superior wall of the duodenal cap about 1 inch from the pylorus; the absence

of symptoms for weeks or months when an unhealed ulcer is known to be present and the occasional occurrence of ulcer symptoms in the absence of ulcer. Certainly the supposition is justified that the behavior of the pyloric sphincter has much to do with the symptoms of ulcer. Is it possible that misbehavior of the sphincter from direct or reflex nervous influence is a factor in the production of duodenal ulcer?

Mere excision of duodenal ulcer has not been followed by satisfactory results, and various types of plastic operations on the pylorus have yielded a large percentage of failures. The reason for failure in the latter may be that the sphincter is rendered only temporarily inactive because subsequent operations have often shown little change in the appearance and caliber of the pylorus. The procedure which Judd has used with eminently satisfactory results in a large number of cases is excision of the ulcer combined with removal of the anterior half of the pyloric sphincter. By this operation sphincteric activity is more or less permanently abolished. There can be no doubt that the removal of a large part of the pyloric sphincter is the major factor in the good results which follow this operation. Excision of the anterior half of the sphincter probably removes many of the local ganglionic cells and the attachments of many sympathetic fibers. It is possible that after a time the sphincter may heal and resume activity. In this event, if certain predisposing factors persist, there may be recurrence of duodenal ulceration. The solution of the permanent control of duodenal ulcer remains involved with its etiology in which dysfunction of the pyloric sphincter resulting from reflex nervous influence should seriously be considered.

Hyperacidity is the most constant laboratory finding in cases of duodenal ulcer. Just what is hyperacidity? Does it mean a larger amount of acid, or acid that is stronger than normal or both? Certain basic facts of the chemistry of the stomach must be kept in mind. The acidity is due entirely to hydrochloric acid. Pavlov showed that the gastric juice as it flows

from the glands possesses a constant acidity—0.5 per cent—never more, never less. The optimum acidity for digestive purposes is 0.2 per cent. The reduction is accomplished by regulation of the amount of acid secreted, by dilution with food and fluid entering the stomach, by neutralization from any alkali in food, fluid, and stomach mucus, and at special times by regurgitation of duodenal contents into the stomach. The acid-secreting mechanism maintains the optimum level of acidity when there is digestive work to be done, and as Pavlov says, the exactitude of the work of the glands is astonishing; that which is demanded of them they furnish each time to a hair's breadth, no more and no less.

Surgical duodenal drainage, evulsion of pancreatic ducts, and formation of a pancreatic fistula are among the most successful experimental methods for the reproduction of peptic ulcer. In these experiments it is a significant fact that one starts with a normal gastric function. Later, in spite of the fact that an ulcer has been produced just beyond the outlet of the stomach, and that all likelihood of duodenal regurgitation has been eliminated, nevertheless gastric function, especially the behavior of the acidity remains unchanged.

In view of these findings can we maintain that ulcer causes hyperacidity? Can there be any doubt that the normal stomach regulates its own acidity? I am aware of no experimental method which has been successful in producing a maintained hyperacidity. From the practical standpoint, hyperacidity means not stronger acid, but the secreting of normal acid beyond the quantity required for digestion and probably when there is no digestive work to be done. Hyperacidity then is really hypersecretion.

Where does the fault lie? Not in the stomach itself. It seems very probable that this dysfunction of gastric secretion originates in the central nervous system, and for reasons not necessary to explain here, it is part of a fixed constitutional pattern. The

psychic phase of gastric secretion produces the most potent juice; it anticipates food in the stomach. "Appetite spells gastric juice." I believe that in the patient with duodenal ulcer the psychic phase of gastric secretion is not only overactive but active at unnatural times. The result in the ulcer patient is a constant effort, conscious or unconscious, to satisfy and neutralize the excessive acidity. Hence the increased appetite, the comfort from food in the stomach and the solace from alkaline powders.

Why do not all persons with hyperacidity have ulcer? Is the ulcer the cause of so-called hyperacidity? Is it responsible for achalasia and spasm of the pyloric sphincter? The symptomatology of duodenal ulcer is explained by hyperacidity and achalasia or spasm of the pyloric sphincter and not by ulcer. Ulcer is the result of the above and not the cause. Removal of the ulcer does not affect hyperacidity nor does it relieve the symptoms, but the latter are cured in many instances by gastroenterostomy even though the ulcer remains for a varying period of time until healing occurs. In the remission periods the patient with duodenal ulcer still has his ulcer although it is probably in a healing stage.

It is not uncommon to see a patient who has the typical symptoms of duodenal ulcer but no ulcer. Reflex spasm of the pyloric sphincter has been known to surgeons for many years. Moynihan painted its word picture in cases of chronic appendicitis. Bastianelli cut the sphincter and relieved patients who had the symptoms of ulcer without actual ulcer. If these patients had been allowed to go on without treatment, would they have developed ulcer? Pylorospasm gives rise to local pain and discomfort, but not to hyperacidity. Spasm of the sphincter is a reflex sympathetic nervous mechanism. Its cause may be any peritoneal irritation, any mechanical derangement, such as partial obstruction, an adherent appendix, an omental attachment to an incisional scar. Food allergy may be a factor—there

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is always spasm of the sphincter during an attack of migraine.

Out of all the experimental work in the search for the cause of chronic duodenal ulcer one fact stands unshaken, that is, that the hydrochloric acid of the stomach has a great influence and is probably the single direct cause of ulcer in the human being. The mechanism and factors by which this is brought about amount essentially to this: hypersecretion of hydrochloric acid, due to a constitutional fault, is combined with failure or inadequacy of the normal safety controls (stomach mucus, alkaline pyloric secretion, and duodenal regurgitation, which carries the strongest alkaline secretion in the body). There is ample evidence of duodenal regurgitation in the normal person, i.e., the frequent finding of bile in the stomach; reverse duodenal peristalsis, demonstrated by the x-ray; and the intractable nature of a postoperative duodenal fistula. Interference with duodenal regurgitation depends primarily upon the pyloric sphincter, either its failure to relax, known as achalasia, or actual spasm. The latter has been frequently demonstrated in patients with duodenal ulcer.

The surgeon does not have to seek outside his clinical experience for a demonstration of the experimental production of peptic ulcer. Every gastrojejunal ulcer is an example of experimental peptic ulcer in the human being.

There have been many types of operations used in the treatment of duodenal ulcer. Their success depends essentially on the control of the hypersecretion of hydrochloric acid. In the evaluation of postoperative results it is important to remember that the patient continues to have hypersecretion although his symptoms may be relieved and his ulcer healed. Simple excision of the duodenal ulcer has been abandoned because of the high rate of recurrence and mere closure of a perforated ulcer is followed by unsatisfactory permanent results in about 35 per cent of cases. Evidently the ulcer alone does not warrant therapeutic attack.

Plastic procedures designed to enlarge the pyloric-duodenal avenue, when well done, have been followed by remarkably few recurrences of ulcer. Their failures have been due to mechanical interference with the emptying of the stomach caused by extensive local adhesions which so often follow these procedures.

Gastroenterostomy almost invariably brings about healing of the original ulcer in the duodenum, but in a varying percentage of cases a new ulcer forms in the jejunum near the anastomotic stoma. We have learned to know that a person with a gastroenterostomy is never free of the potential danger of a marginal ulcer. I have notes of a patient who was under my care for this condition twenty-eight years after a gastroenterostomy had been done for duodenal ulcer. The answer to the failures after gastroenterostomy may be found in the explanation of its successes. I have no doubt that the successful surgical treatment of duodenal ulcer by any type of operation depends upon efficient control of hyperacidity. The test of this does not lie in the results of gastric analysis but in the continued well-being of the patient. No operation yet devised can alter the cerebral stimulus upon which hyperacidity depends.

It is a human failing to carry on to extremes, even in therapeutics. An example of this is the practice of partial gastrectomy for duodenal ulcer. The stated reasons have to do with removal of the ulcer-bearing area of the stomach and duodenum and its associated gastritis, and with a supposed control of hyperacidity by removal of part of the secretory area of the stomach. Gastritis has nothing to do with the cause of ulcer although the two may have a common origin. Removal of part of the secretory area does not slow up the activity of the part that remains, which actually may undergo functional hypertrophy. Marginal ulcer may occur after partial gastrectomy for duodenal ulcer and its incidence is almost the same as when gastroenterostomy has been done in well selected cases. If anything can be said in justification for gastrectomy for ulcer in



the duodenum, it is that its mechanics insure more adequate neutralization of gastric acidity. But the sacrifice of three-fourths of the stomach is a big price to pay for the removal of a small ulcer in the duodenum.

Assuming that the background of duodenal ulcer with its associated perversion of gastric physiology is of the nature depicted elsewhere in this paper, what is a logical solution to the problem? If hyperacidity and dysfunction of the pyloric sphincter are at fault, is there any method to correct them? So far there is no mechanical means to attack the basic fault of hyperacidity. In duodenal regurgitation nature has its own method of control, but in the ulcer patient its action is prevented by the pyloric sphincter. This is not a new thought—surgeons long ago tried to render the sphincter inactive by cutting its fibers. The results were immediately good, but were only temporary, because after healing the sphincter resumed its former activity. The method of Judd by which the anterior half of the sphincter is removed comes very near the ideal procedure. Its success in cases in which it can be done far surpasses any other operation for ulcer. Its small percentage of failures is due not to recurrence of ulcer but to mechanical factors incident to local adhesions. Judd's operation opens the stomach and duodenum and is completed as a gastroduodenostomy. It is liable to the same faults due to adhesions which have followed other plastic procedures on the pylorus.

The ideal method to obtain our objective is removal of the anterior half of the pyloric sphincter without opening the stomach or duodenum. This we have done by a method described elsewhere, with excellent results. The sphincter has been rendered permanently inactive or at least no longer interferes with duodenal regurgitation. The operation is suitable only for those duodenal ulcers in which extensive scar tissue and fibrosis are absent. Otherwise identity and removal of the anterior half of the sphincter are not practical.

#### SUMMARY

The pyloric sphincter is composed of constrictor and dilator muscle fibers, the former under the control of the sympathetic nerves and the latter under the parasympathetic or vagus nerves. The sphincter plays a part in the emptying of the stomach and also in the regurgitation of duodenal contents into the stomach. Its mechanism may be disturbed by local or reflex irritation. Many of the clinical features of duodenal ulcer can be explained by the activity of the pyloric sphincter. It may cause the typical symptoms of ulcer when no ulcer is present, since the ulcer itself does not cause the symptoms which identify its presence.

Dysfunction of the pyloric sphincter is one of the two main factors in the etiology of duodenal ulcer. The other factor is hyperacidity. The normal stomach regulates its own acidity. In certain individuals hypersecretion is a fixed constitutional fault and its control rests on the mechanism of duodenal regurgitation. Failure of this control means the development and maintenance of a duodenal ulcer. The pyloric sphincter because of spasm or failure to relax becomes a potent hindrance to the regurgitation of alkaline duodenal contents into the stomach.

Successful treatment of duodenal ulcer depends on the control of hypersecretion. The administration of antacids and the use of sedative measures to slow up the cerebral stimulus constitute the accepted medical treatment, but failure is common. Surgical measures have been designed to utilize the patient's own control mechanism. Failure means the development of a new ulcer. Of the two factors concerned in the etiology and maintenance of duodenal ulcer, dysfunction of the pyloric sphincter alone is amenable to direct attack. Its function can be abolished permanently by a simple operation which removes the anterior half of the sphincter without opening into the duodenum or stomach. This procedure has been carried out with enduring success in cases of duodenal ulcer.



# EXPLORATORY LAPAROTOMY

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THE title of this article is self-explanatory—a laparotomy undertaken before a diagnosis has been made. With our modern methods of diagnosis it is perhaps true that the need for the performance of such an operation is less frequent than formerly. Still we are forced, much to our chagrin, to admit that today, even in the best clinics of the world, exploratory laparotomy is far from being an infrequent operation. And it is highly probable that it is of greater frequency in the better clinics for the simple reason that the cases in which it comes to be indicated, particularly those wherein it is not immediately indicated, are likely to be referred in greater numbers to the greater clinics. The indications for an exploratory laparotomy may vary a good deal in various hospitals, and “they vary with the skill, qualifications, temperament and conscience of the surgeon in charge of the case” (Schnitzler). But there are clear-cut indications for the performance of such an operation and also certain contraindications.

An exploration of the abdomen by surgical operation is indicated for therapeutic purpose in any chronic *intra-abdominal* condition thought to be relivable by surgical means, but the exact diagnosis of which has not been arrived at after the exhaustion of all the skill and methods that medicine has to offer. It is also indicated in any acute abdominal case, thought to be surgical, wherein the time lost in waiting for the performance of the various diagnostic tests and manipulations in ordinary use, or where the very tests and manipulations themselves might increase the risk to the patient's life. Also in certain cases in which the diagnosis has already been established (e.g., cancer of the rectum, etc.)

but where the extent of involvement is unknown and hence the proper form of therapy cannot otherwise be agreed upon.

It is strongly contraindicated when the surgeon has reason to feel that the operation, while it may make the diagnosis positive, yet cannot hope to give relief. Never should an exploratory laparotomy be done for biopsy only; and it is also strongly contraindicated when there is reasonable certainty that the condition of the patient will be made worse thereby.

Attempts have been made in the past, and let us hope will continue to be made in the future, to discover some means to enable us at least to arrive at a diagnosis, and, if possible, administer therapy in some other way than by recourse to a major operation. The invention of the cystoscope by Nitze in 1876 has, I believe, been responsible for saving and prolonging more lives than were lost altogether by war and pestilence ever since. Kelling, in 1901, applied the same instrument—modified—to intra-abdominal diagnosis and since then, from time to time, in various countries reports of improvements of technique and instrument have been brought to our notice. But as yet there is no place where its use has become so accurate as to displace exploratory laparotomy. The gastro-scope is at present exciting about as much attention as the gastroduaphane did some thirty or forty years ago (which is not saying a great deal), but the proctoscope and sigmoidoscope are second only to the cystoscope for the illumination of hitherto dark areas in the field of diagnosis. There is no doubt, however, that these means, and particularly the x-ray with the barium meal or enema and later pneumoperitoneum and the Graham gall-bladder test

have been responsible for the tremendous advance that has been made in abdominal diagnosis in the past forty years.

It has been clearly stated that exploratory operation is indicated only in *intra-abdominal* disease or injury. We shall consider the acute conditions first because of the great importance in these of an early answer to the question of diagnosis. Let us keep in mind the fact that there are pathologic conditions elsewhere that may betray their presence only by intra-abdominal symptoms. The chest is often the abode of such processes. Who has not seen the early pneumonia, particularly in the child, mistaken for acute appendicitis? The key to the differentiation is in the careful examination. The high fever, increased respiration, the very high white count, the absence of deep tenderness, and the presence of chest findings are most unusual in acute appendicitis, while nausea, rigid rectus and tenderness, particularly on deep pressure are very common accompaniments of acute appendicitis. A deep inspiration can hardly be made at all by one with acutely inflamed lung or pleura and its forced attempt fails in a grunt or slight cough, whereas in acute appendicitis only the *lower* abdomen remains quiet with deep inspiration—no cough and no increased pain are present. Particularly in children, there is the acute peritonitis that accompanies "flu" or follows tonsillitis. This should remain a medical case throughout. An operation is altogether too frequently followed by a funeral.

Most dramatic and most terrible is the resemblance between the acute abdominal catastrophe and the acute cardiac crisis. Angina pectoris, coronary thrombosis—the very names strike a chill to the heart of every physician over fifty, and every medical student early becomes familiar with their history, symptoms and sequentia. Can it be possible that an exploratory laparotomy could ever be performed in these conditions or in that of acute cardiac dilatation? It surely has been done and in all probability will be again. There

are many cases cited in the literature. Here is one from St. Mary's hospital:

CASE I. C. V., male, 42 years old, a salesman, was carried in complaining of terrific abdominal pain, worse in the epigastrium, which had begun three hours before, just after lunch. Nausea and vomiting were present. He was of stocky build, not fat, and had always been healthy and industrious. He had eaten a hearty lunch and had got into his auto to go to work. He felt nauseated and opened the door, then remembered no more till he was being lifted from the street beside his car, when he began to scream with the pain in his abdomen. A physician gave  $\frac{1}{4}$  gr. of morphine by hypo and after half an hour repeated it because of the terrible pain.

The abdomen was rigid, the muscles tense, and the nausea persisted. W.B.C. numbered 17,000 (infectious picture); temperature was 100.6, pulse 76, and blood pressure 110/85. There was not the expected tenderness. An x-ray revealed no free gas and operation was considered inadvisable. A nasal tube was inserted and the stomach kept empty.

Next morning he was symptom-free but a little nervous. The third morning he was hungry and thirsty, but the temperature was 101.8, pulse 132, respiration 24, and a mass was present in epigastrium and right upper quadrant. The abdomen was distended and very tender in that area, and the white blood cells were 17,700.

The patient was taken to the operating room. After failure of spinal anesthesia, ether was used. He became cyanosed and remained so. The abdomen was opened. The liver was enormous and purple, the gall-bladder, pylorus and duodenum were normal. A cystic mass, 2 inches in diameter, of robin's egg blue was seen behind the peritoneum to the right of the duodenum and in the edge of the gastrohepatic omentum. Aspiration drew dark blood from it but did not diminish its size (the portal vein or the vena cava?)! The wound was closed, and the patient died within the hour. The post-mortem showed coronary thrombosis with dilated heart.

And just to show the converse, the following is cited:

CASE II. A. F., male, 54 years old, a real estate man, known for years to have duodenal

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ulcer, at last decided to be operated upon. About seven o'clock of the evening before operation he was suddenly stricken with terrific pain in the left side of the chest, neck and left arm and leg, and at once went into shock with copious sweating. The abdomen was neither tender nor rigid. The handling of it annoyed him and he begged to be let alone. He lay quietly and constantly on his right side with abdomen slightly turned to the bed. The diagnosis was angina pectoris. We didn't know enough then of the value of an x-ray plate. He died in eight hours and the post-mortem revealed a perforation 2 cm. in diameter in a duodenal ulcer!

These are hard cases to diagnose because the symptoms all seem to indicate with unerring certainty the site of the disease. But even in the most clear-cut case we ought to think of the possibility of error. There are two aids now nearly always available. The electrocardiogram is pretty certain to reveal any serious cardiac disease and the x-ray, showing free gas in the cavity, says positively that the gastrointestinal tube has been ruptured. Of course, there is not always gas, but when there isn't, the perforation is not leaking very much. It has been said that the pallor of the acute cardiac crisis contrasts as a rule with the ashen cyanosis of acute pancreatitis. It is often true, but the cases cited above show that it is not always so. And while most exquisite tenderness in the region of the liver, together with or preceding its rapid enlargement, is very common in acute cardiac dilatation, yet this tenderness is uniform even to the right lower margin, but in the upper abdominal catastrophe the tenderness is always greatest over the site of the disease and spreads from there as the hours pass.

Among rare conditions one must think of are angioneurotic oedema or purpura with gastrointestinal lesions. There is nausea and always severe, cramp-like pain and, maybe, rigidity of the abdomen. The intestine is usually active and borborygmi can be heard—and presently the enema brings bloody stool. This is not

easy to differentiate, but the short clotting time and long bleeding time might make us at least think of purpura.

An acute abdominal crisis often follows within an hour after the "black widow" spider bite. The symptoms have led to laparotomy but even though nausea, vomiting or cramp-like pain is present, with muscular hypertension, one should notice that the rigidity is not confined to the abdominal muscles.

An exploratory laparotomy for vomiting alone should never be undertaken until all toxic causes, not forgetting uremia, and, in the female, pregnancy, have been ruled out. Just to think of the possibility will positively prevent one from making the mistake. But vomiting alone may be the only symptom in the patient with a high obstruction or an internal strangulation of omentum, or one which does not include the whole gut.

There are diseases of the nervous system which give rise to crises of severe abdominal pain, and even to abdominal pathology. All are familiar with the fact that there are gastric crises in tabes dorsalis and other spinal cord diseases, but not so many know that the abdomen has been opened and appendix or gall-bladder removed for crises of abdominal pain caused by a brain tumor! Indeed it is true that pathology in, or operations on certain parts of the brain have been the cause of perforating ulcers in stomach, duodenum or large bowel. The latter I have had in my own practice. And for the upper parts of the tract there are many cases cited by Cushing and others. I have seen acute spinal meningitis very closely simulate an acute abdominal inflammation. It was the hyperesthetic skin of legs and feet and the lack of tenderness (deep) that made us look for other signs and prevented an immediate laparotomy. To think of the possibility enables us to avoid any mistake, for these diseases of the central nervous system usually have other characteristic signs and symptoms.

Acidosis preceding diabetic coma has been accompanied by abdominal symp-

toms and signs suggesting acute catastrophe, and the abdomen has been opened to find no pathology present. Fever may be present, with a high white count; in fact, the white count has been as high as 50,000, and has been accompanied by nausea, vomiting and pain. A urinalysis nearly always reveals the truth, but the blood sugar never fails to do so. The unfortunate fact remains that diabetics do sometimes have real pathology in their abdomens.

A crisis due to lead colic will not lead us astray. The low white count, low temperature, slow pulse, the blue line in the gums and stippled red cells and the rolling and writhing about of the patient, consign him to the care of the physician.

Very often indeed an operation for an acute abdominal catastrophe must be an exploratory laparotomy. The thing to be certain of is that its pathology is intra-abdominal. The case is so urgent, since, if relief is to be of value, it must be given at the earliest possible time after the onset of the disease. To lose valuable time in making tests and even the very procedure of making the tests, e.g., x-ray, gastrointestinal examination, etc.—may lessen the chance of saving the life of the patient. While it is desirable to make certain of the diagnosis before operation, to take the time and use the means necessary to enable us to do so might allow the disease or condition to progress to such a point that no surgeon in the world could save that patient's life by operation. We must still be strong in the opinion, "It is better to look and see than to wait and see." It is much better to operate without a diagnosis and prevent death than to wait for the correct diagnosis and have a funeral. After all, it does not make much difference to the surgeon whether it be a gangrenous gut or gall-bladder, a perforated ulcer or an acute appendix, a cyst with a twisted pedicle or an acute pancreatitis. But there are some conditions that he must make sure it is not. Of some of these we have spoken, and there are three or four more which may

lead to an operation followed by regret or even remorse.

The stone in the ureter and the acute pyosalpinx or the parametritis following abortion are dangerous pitfalls. The urologist can now exclude the former very definitely. The radiation of the pain, the aching in the loin and the complaint of a sense of fatigue should serve to put us on guard against kidney or ureter. The parametritis infections have the habit of starting off with chill and high fever, and the pelvic examination usually decides the diagnosis and defers the operation. An acute diverticulitis of the sigmoid should be excluded before one decides to explore an acute case. The location, the pain and soreness, the preceding constipation and the fever should aid us. The x-ray with barium enema, taken in the acute stage, is likely to be reported as "a filling defect," but carcinoma there doesn't present the picture of an acute abdomen.

In these acute abdominal crises, one must operate without waiting for the certain diagnosis. Only be certain that it is intra-abdominal and that it is a surgical condition. There is no other situation in his life which tests the surgeon like one of these: if he operates and fails to find pathology he loses his reputation, but if pathology be present and he doesn't operate the patient may lose his life. And when he fails to find pathology and the patient loses his life as a consequence of the operation, that is worst of all. If he waits to make certain of his diagnosis he will unfortunately most likely have it confirmed at the post-mortem—rather poor satisfaction.

So much for the acute abdominal crisis of intraabdominal origin. I have purposely refrained from rehearsing the signs and symptoms. The operation gives the best hope of saving life in all of these acute conditions, and usually the earlier the better—usually, but not always. Not while the patient is in shock and untreated for it. Naturally, I am not including acute intestinal obstruction among the conditions in which exploratory laparotomy is indicated,

as it should be, and usually is, easily diagnosed before operation.

There are some conditions in which the indication for exploratory laparotomy may be debated—acute hematemesis of unknown origin is one, and suspected subdiaphragmatic suppuration is another. In the first, one must remember that the cause may be unrelievable by surgical operation and that when the cause cannot be found with our present methods—that is to say, when the diagnosis cannot be made—the case is best treated medically. In the subdiaphragmatic suppuration the outlook under medical care is so bad that the patient has more to hope for from proper exploration.

The exploratory laparotomy is indicated in certain intra-abdominal injuries. There may exist a wound of the parietes or not. Suppose that not even a contusion can be found, but there is a history of recent injury and the patient presents signs of intra-peritoneal irritation or of loss of blood and is getting worse. I feel sure one should not wait longer than five or six hours before exploring. There is, I think, no viscus within the abdomen or pelvis that has not been accidentally ruptured without a surface sign of injury. But the history is always there and the symptoms appear in time to show the danger, but they may not be perceived. The abdominal muscles become rigid, peristalsis slows down or ceases entirely in the region of foreign matter within the cavity, pain and tenderness come later and usually still later the nausea and vomiting. Has the urine been examined for blood? Has the bladder capacity been tested to determine that its walls are still intact? When the kidney alone is ruptured without tear of the peritoneum the signs of peritonitis do not supervene, but when the gastrointestinal tube is broken the x-ray will soon reveal free gas.

In all cases of gunshot, stab, or other wounds of the abdominal wall, or in cases of such wounds of near lying parts of the body, if one has reason to suspect that the

abdominal cavity has been penetrated, there is no argument about it: the abdomen should be opened and explored just as soon as possible. In such early cases, shock, if present, is likely to be increased by, if not due entirely to, the loss of blood. Therefore, a transfusion and an exploratory laparotomy should be begun without loss of time.

There are also chronic conditions arising within the abdomen wherein the physician, after exhausting all the means of making a diagnosis, is unable to say positively just what the condition is. He may fear that while he is waiting for the advent of such signs or symptoms as will enable him to be assured, the disease may make such progress as to place the patient beyond the hope of help. In all such instances, exploratory laparotomy is indicated.

Here I would warn all, but especially the young surgeon, against that class of patients—and they are very numerous—who speak so convincingly of their terrible sufferings (Dr. C. H. Mayo said "They enjoy poor health, their folks suffer."), that one might be forgiven for making a diagnosis of chronic appendicitis or of almost anything very serious. They have symptoms, perhaps signs too, but usually the most painstaking and complete search at laparotomy fails to reveal pathology. "Methinks he (or she) doth protest too much" to have need for exploration. The first operation on the neurotic is one of a series and very rarely indeed is pathology found to explain the symptoms. When one has failed to find pathology he has done an unnecessary operation.

There are some cases of chronic abdominal pain that have ample reason for being and they may perhaps be relieved by an exploratory operation. In all such, we must be certain that disease of the cord or of its membranes, of the spine or ribs and of the kidneys are excluded. Inflammations usually give more than pain, but often neoplasms do not give much else.

Then there are conditions wherein exploratory laparotomy is indicated but the fact is not yet generally agreed upon. Let

me give special consideration to cancer of the stomach. The popular operation for cancer of the stomach in our country today is simple gastroenterostomy. Numerous patients who have had gastric resections live for five years or more, but it must be borne in mind that these are *carefully selected cases*. However, the bulletins of the clinical society, listing the work for the day, show very few operations for cancer of the stomach, and of these, the scheduled gastrectomy often turns out to be a simple gastroenterostomy. I have seen only a few cases of cancer of the stomach in which the diagnosis was made before operation, in which the disease had not already progressed beyond the point of possible cure. This being so, we must admit that its diagnosis is not being made early enough.

In order to help to save more lives from this disease, let me say here that every case of suddenly appearing stomach trouble in a man (or woman) over forty-five which doesn't respond to proper medical care within a period of four weeks, should be subjected to exploratory laparotomy. We should not wait longer for the appearance of physical signs—the x-ray reveals the cancer only when it is larger. Unfortunately, we wait for the report containing those most sinister words, "There is a filling defect." This short sentence is usually a sentence of death! In the present condition of our ignorance, early exploratory laparotomy for all stomach cancer suspects will do for cancer of the stomach what has been done for breast cancer. And we must strive to make this the practice. The person in the cancer age who has all his life been free from stomach trouble and for the first time begins to have serious stomach complaint, is always a cancer suspect, and as soon as we come to realize this the prognosis in cancer of the stomach will be better.

In certain cases of chronic jaundice an operation is indicated for both diagnosis and treatment—in certain others for treatment alone. It has been said that painless jaundice has malignant disease for its

cause, but this is not always true. Furthermore, there is no known test or method of examination whereby one may, in the absence of palpable tumor, be assured of the existence of cancer of the papilla or of the pancreas or of the absence of a stone. If one does not know the cause of the jaundice, but one is certain that it is of the obstructive type, that is sufficient reason for exploratory laparotomy (providing the patient is not hopelessly ill). Many such obstructions have I found due to removable and curable strictures and stones, and some supposed even at operation to be cancers of the pancreas have been cured by anastomosing the gall-bladder to duodenum or stomach. That is to say, cancer of the pancreas was not present at all, as the following case will show:

CASE 111. S. T., male, 54 years old, a lawyer, tall, well built, who weighed 200 pounds but whose best weight was 230 pounds, complained of nausea and vomiting and dull, aching pain in the right upper quadrant. His appetite, usually good, had become poor. His bowels, previously constipated, were now diarrheic, the stool grayish and very foul. Urination was normal. General examination proved negative, except for slight tenderness in the epigastrium to the right of the midline. R.B.C. were 5,320,000, W.B.C. 5,200. Hemoglobin was 80 per cent, clotting time three and three-quarter minutes, blood pressure 142/88, N.P.N. 43, blood sugar 125, Wassermann negative, icterus index 23, Graham test negative. The urine was acid with specific gravity of 1.016; albumin plus; a trace of sugar; some red and white cells, but no casts.

Diagnosis could be chronic pancreatitis, chronic hepatitis or cancer of pancreas.

An exploratory laparotomy was done. The liver was seen to be somewhat shrunk with thick rounded edges and thickened capsule. The gall-bladder contained black bile, with no concretions or adhesions. The stomach was free, with neither scar nor masses. The pylorus was smooth and the duodenum was wider than normal and seemed dilated. The head of the pancreas was very hard and somewhat larger than normal. The diagnosis at the table was probable cancer of the pancreas obstructing both the duodenum and the common bile duct.



The fundus of the gall-bladder was anastomosed to the anterior wall of the stomach in the prepyloric region. A posterior contraperistaltic gastrojejunostomy was done. The patient recovered.

He returned to the hospital in 1932 to be treated for food poisoning. In 1934, he returned again because of rupture of the columnae carnae or chordae tendinae. Again in the same year he was treated for acute cardiac dilatation. In 1935 he sustained an injury in an automobile accident and was brought to the hospital with fracture of the ribs, lung injury, fracture of the radius and mild concussion. He returned again in 1936 with novocaine poisoning following tooth extraction, and again that same year, for auricular fibrillation. In March of 1937 he was treated at the hospital for diarrhea, and two months later for cardiac dilatation which caused death.

The post-mortem revealed a thick-walled gall-bladder, empty, anastomosis with good stoma about 5 mm. in diameter, the pancreas normal with no increased firmness.

This is just one example, but in my experience there have been many others in which it was utterly impossible to make a diagnosis without an operation, and although (as is shown by the history) the correct diagnosis was not made even at operation, yet a therapeutic measure was instituted then and there which, as far as I know, was the simplest, safest, and most logical that could have been carried out with any hope of making the patient more comfortable should he prove to have cancer of the pancreas, or of curing the condition should it prove to be chronic pancreatitis.

Again comes the patient who has had an epileptic or epileptoid seizure and is found to have hypoglycemia. There is no way of determining the presence or absence of an adenoma of the pancreas except by operation; and no way of curing the case without operation should an adenoma be present. An exploratory laparotomy is indicated.

Certain cases of ascites in women are due to rupture of an ovarian cyst. Papilliferous carcinoma or even pseudomucin escapes into the peritoneal cavity and ascites is the result. In either event the best treatment is

early removal of the cyst, and often only by exploratory laparotomy can early diagnosis be made. Or, if it were ascites due to liver cirrhosis, it has been proved over and over that the Talma Morrison procedure, if used early, is most beneficial. A contraindication to the operation in ascites would be the ascites due to heart failure, or heart failure in any kind of ascites.

There is another set of circumstances in which I think early exploration should be the rule, and only the surgeon in the case can know how much one hates to have to perform such an operation. This is a post-operative exploration.

Let us suppose the patient has been making a normal recovery from, or convalescence after, his operation. Suddenly something happens which should not happen in normal conditions. Pain, collapse, nausea with or without vomiting may occur. Flatus may cease passing or the patient may visibly bleed. Any one of these symptoms or signs means that there is some serious deviation from the normal. The time to make the diagnosis and administer proper treatment is in the early hours. In the first twenty-four hours after operation, it is true, collapse may be a signal of failing heart in which case an operation would probably cause death. Consequently, no exploratory operation should be performed under these circumstances. When, however, acute cardiac failure can be excluded, when one can be certain that the cause of the symptoms is intra-abdominal, it is the part of wisdom not to hesitate, but to operate at once.

#### SUMMARY

There are very clear-cut indications for exploratory laparotomy. With all of the diagnostic aids in use at present and even with the maximum amount of skill on the part of the physician, conditions arise which are not possible of diagnosis without exploratory laparotomy.

Care is needed lest exploratory laparotomy be performed when the lesion is elsewhere than in the abdomen.

In the chronic cases, all of the evidence available otherwise must be obtained. Such a case is usually not urgent and there should never be haste in deciding to explore.

The acute surgical abdomen and all that is comprised under this title is of such a nature that exact diagnosis cannot be made in time to save the patient's life. Early exploration should be the rule.

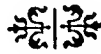
Every instance of suddenly appearing stomach trouble in a patient over forty-five in which diagnosis cannot be made or which does not respond to proper medical treatment within a period of four weeks, should be subjected to exploratory laparotomy. To wait for the x-ray to make certain of the diagnosis will often lead to the death of the patient. In the present condition of our ignorance, exploration of all stomach cancer

suspects will do for cancer of the stomach what has been done for breast cancer.

The jaundiced patient who has never had a history of gallstones and who has jaundice without pain may not have cancer of the pancreas, all opinion to the contrary notwithstanding, and his condition may be relievable by surgical means. An exploratory laparotomy is indicated.

Any penetrating wound of the abdomen should be explored immediately. Any other abdominal injury which fails to improve after six hours should be subjected to exploration.

No exploratory laparotomy should ever be done merely for the sake of making the diagnosis or of confirming a hopeless one. The reason for the performance of the operation must always be for the benefit of the patient.





# SCLEROTHERAPY FOR PILONIDAL CYST\*

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THE success of sclerosive therapy in varicose veins has stimulated the reapplication of this method of treatment to allied conditions. The injection treatment of bursae, hemorrhoids, hydrocele, and hernia, represents some of the newer trends in chemical surgery. In 1933 Cutler and Zollinger<sup>1</sup> revived the ancient method of treating pilonidal cyst by the use of irritating solutions. Their success prompted me to study this problem, and the results obtained justify the report on which this article is based.

The term pilonidal was applied to this developmental anomaly by Hodges. Actually, it means a nest of hair. These hairs frequently protrude from sinus openings, or may be found at the cystic dilatation which is frequently present. It is now recognized that these congenital depressions are due to faulty fusion of ectoderm in the sacrococcygeal region. It is not generally known that almost one-third of infants, at birth, show a sinus in this area. Usually it disappears with growth, but in about 4 per cent of cases, especially in males, the defect persists.

The sinuses may be single or multiple, and vary in depth from a few millimeters to more than an inch. Cystic dilatations may be present at any point of the sinus; usually at the end of the passage. When multiple sinuses are present, they will be found to communicate with the same blind cystic pouch. It is important to keep this fact in mind during the treatment.

It is interesting to note the ancient origin of sclerosive therapy, and its recent

revival. As far back as 1829, Dzondi<sup>2</sup> treated a fistula of the neck by injecting liquor nitrici hydrargyri. Apparently this method of treatment proved discouraging, because there is no evidence of its continuation in the literature of that time.

The neurologic surgeons must be credited with the stimulus for the modern approach to the problem. It had been noticed that solutions of the type of Zenker's<sup>3</sup> and Carnoy's<sup>4</sup> would fix the lining of certain forms of gliomatous cysts. As a result, the tissues became tougher, and were more easily removed surgically. In addition these solutions showed definite hemostatic qualities. These properties were seized upon by Cutler and Zollinger for their treatment of cysts and fistulae.

The possibility of replacing surgery by a simple sclerosing procedure led me to attempt the duplication of Cutler's method. In the procedure as outlined by the authors, the abscesses were first incised and drained. Following this, modified Carnoy's solution was applied to the abscessed cavity, which was subsequently curetted. The sinus tracts were also laid open, after which the cauterizing solution was applied to the lining membrane. This was again followed by curettage and further chemical treatment. Their method gave good results. However, it involved open surgery, which, although of a minor

<sup>2</sup> DZONDI, C. H. On congenital fistula of the trachea. Schwetsche & Son, 1829; Reproduced in the British Record of Obstetric Medicine & Surgery for 1848, vol. 1.

<sup>3</sup> Zenker's Solution: A fixative solution of corrosive sublimate (5 parts); potassium bichromate (2½ parts); sodium sulfate (1 part); water (100).

<sup>4</sup> Modified Carnoy's Solution: absolute alcohol—6 c.c.; chloroform—3 c.c.; glacial acetic acid—1 c.c.; ferric chloride—1 Gm.

<sup>1</sup> CUTLER, E. C., and ZOLLINGER, R. The use of sclerosing solution in the treatment of cysts and fistulae. *Am. J. Surg.*, 19: 411 (March) 1933.

nature, was the very thing I wished to avoid.

Of the three cases reported here the

The sinuses must first be probed until they are sufficiently wide to admit very fine curettes. Instead of probes, fine



FIG. 1. Infected pilonidal cyst incised, cavity packed with iodiform gauze. Note gauze in abscessed cavity.

first had a frank suppurative process and was incised. The other two patients had no abscess and were successfully treated without incision.

#### TECHNIQUE

Patients will usually report for treatment after infection has occurred. However, in some cases, the presence of slight swelling, or history of a discharge, may bring the patient under observation. Routine physical examination may also disclose the presence of small sinuses before symptoms appear. This technique may be applied at any of these stages.

The rare condition of spina bifida should be ruled out before attempting treatment. The remote possibility of a congenital cyst communicating with the dura or a meningocele can be excluded by simple x-ray examination. The area should then be closely studied to learn the location of all the sinus openings. Sometimes, during treatment a tract will be disclosed which was invisible at the outset. Infected areas should be incised and drained before sclerosive therapy is instituted.

needles may be employed which have had their tips dulled by grinding. Probing should be continued until the common cystic enlargement of the sinuses is found. Modified Carnoy's solution is then injected, using a dull needle which is inserted into one of the sinuses. Enough solution is injected to fill all the tracts. At the next treatment each tract is curetted with a very fine curette or the following substitute: A needle with a long bevel is deliberately bent so that the tip becomes deflected to form a slight burr or hook. This catch on the needle tip may be employed as a curette by being run forwards and backwards in the sinus canal. It is advisable to use preliminary anesthesia. Two per cent nupercaine solution should be carried into each sinus on a fine cotton-tipped probe.

Following the curettage, the sclerosing agent, fuming nitric acid is applied. At the outset of this technique I employed the modified Carnoy's solution advocated by Cutler and Zollinger. However, it was soon discovered that this preparation did not have enough sclerotic power for this

procedure in sinuses. Apparently a stronger caustic was necessary, and fuming nitric acid was decided upon. It is applied on a

the cavity was clean and almost closed. Three weeks later three sinus openings were located, curetted, and treated with fuming nitric acid.

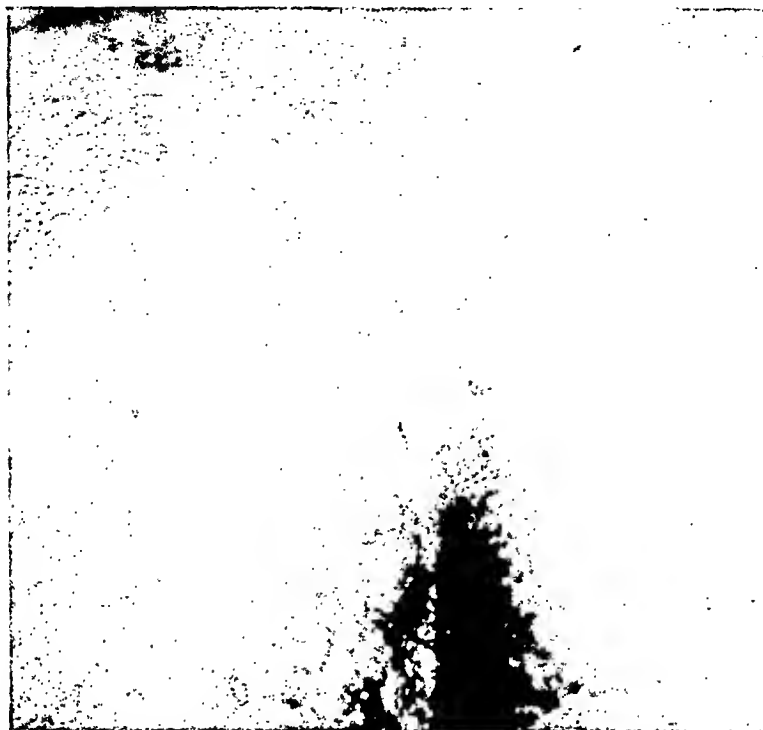


FIG. 2. Healed. Note scar tissue at site of abscess and sinus openings.

probe or fine metal applicator, which has been dipped into the acid, and the excess drops removed. A thin film of acid remains on the metal tip of the instrument. After curettage this is inserted to the depth of the canal, and the metal rotated, bringing the solution in contact with the entire circumference of the lining cavity. Curiously enough this procedure is not painful, the patient experiencing only a slight burning sensation. Treatments are given every two to four weeks until complete obliteration ensues.

#### CASE REPORTS

**CASE I.** Age 16. An abscess had been present in the sacrococcygeal region for one week. The swelling was incised under local anesthesia and the cavity packed with iodoform gauze. (Fig. 1.) Three days later the abscessed cavity was smaller, and was cleaned. Modified Carnoy's solution was applied for ten seconds on a cotton-tipped applicator. Two sinuses were discovered leading into cavity. Two weeks later

The largest sinus, when probed, was found to be 2 inches long. Long hairs were removed when this sinus was curetted. Two weeks later curettage and cauterization were performed. One month later one sinus closed and the remaining two were treated. One month later the largest sinus was still slightly open. It was curetted and nitric acid applied. One month later the pilonidal cyst was completely cured. The sinus openings exhibit firm scar tissue; the probe cannot be pushed in. (Fig. 2.) A check-up one year later disclosed no recurrence.

**CASE II.** Age 30. Patient complained of a discharge on underwear, slight itching, and discomfort in the sacrococcygeal region. Examination disclosed a pilonidal cyst with two sinuses. No active infection was present. It was decided to institute sclerotic treatment immediately after the sinuses were probed. After two preliminary probings, to ascertain length and direction of sinuses, the first treatment was instituted. Modified Carnoy's solution was injected through the sinus opening, using a dull-tipped needle. Two weeks later both sinuses were curetted (under nupercaine anesthesia)

with the removal of numerous hairs and lining membrane. Following this, fuming nitric acid was applied on an ordinary metal applicator tip, deeply into both sinuses. The sinus openings were dressed with a small gauze pad containing boric acid ointment.

Two weeks later the same procedure was performed. One month later, on attempting curettage, it was found difficult to enter the sinus tracts, because of beginning obliteration. The probe containing the nitric acid was admitted partly into each tract. A dry dressing was applied. One month later both sinus openings were completely closed. A check-up one year later disclosed no recurrence.

CASE III. Age 33. This patient complained of itching and discharge in the sacrococcygeal region for several years. Examination disclosed a pilonidal cyst with two sinus openings. These were probed to the point of common intersection several times, then modified Carnoy's solution was injected. One week later the sinus tracts were curetted, using a needle which had been deliberately bent at its tip. Fuming nitric

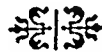
acid was applied on a probe into each sinus tract. Two weeks later another treatment was given. The third treatment was given one month later. The sinus openings were smaller and difficulty was experienced in introducing the probes. When the patient was seen one month later, both sinus openings were firmly closed, and the patient discharged. Six months later the patient was re-examined with the same findings.

#### SUMMARY

1. A modification of the method of Cutler and Zollinger for the injection treatment of pilonidal cyst is presented.

2. The method is non-surgical and depends upon the cauterizing action of fuming nitric acid when it is applied to the sinus tracts.

3. Check-up examination after a year discloses the permanency of the end result with this method.



# THE USE OF ALKYL-DIMETHYL-BENZYL-AMMONIUM CHLORIDE IN INJURY\*

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AND

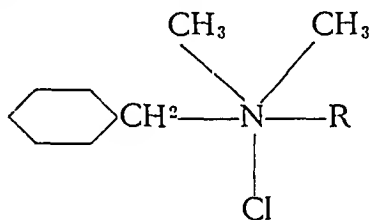
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IN 1935, Gerhardt Domagk<sup>1</sup> introduced an entirely new type of germicide. The compound is a mixture of alkyl-dimethyl-benzyl-ammonium chlorides in which the alkyl group represents a series of homologous radicals derived from the fatty acids of coconut oil. It is a brand of dial konium (zephiran). While the antiseptic properties of coconut oil are well known, the combination with quarternary ammonium base had theretofore not been investigated.



The compound is an amber-colored solid of soap-like consistency, which is quite uniform in composition. It is soluble in water, alcohol and acetone. Solutions in germicidal concentrations impart a soap-like sensation to the skin, leaving it smooth and satiny. Germicidal solutions for clinical use have a surface tension of less than 36 dynes per c.c., as compared to distilled water which has a surface tension of 70 dynes per c.c. at room temperature.

Extensive pharmacologic and toxicologic studies were carried out by Deskowitz.<sup>2</sup> Solutions of 1:1000 were given by mouth to guinea-pigs as their only source of fluid for months without any deleterious effects upon health. Microscopic examination of the organs was negative. A 1:1,000 solution injected intraperitoneally (up to 6 c.c.) daily for several months caused no reaction, while more concentrated solutions caused a

fibrinous reaction. A 1:1,000 solution applied to a rabbit's shaved ear and allowed to dry, revealed no irritation. The 1:1,000 dilution in the form of gauge packs was the highest concentration that could be applied for twenty-four hours to the ear with slight evidence of irritation resulting.

Dunn<sup>3,4,5</sup> and Heineman<sup>6</sup> reported that alkyl-dimethyl-benzyl ammonium chloride possessed a high germicidal potency against a variety of pathogenic organisms. Penetration and inhibition tests, conducted by Heineman, were made according to the agar cup-plate method of the United States Government Food and Drug Administration. *Staphylococcus aureus* was inhibited in a concentration of 1:100,000 both in plain and serum agar. *E. typhosa* was inhibited in a concentration of 1:5,000 but not in a concentration of 1:10,000.

White<sup>7</sup> and his co-workers found in clinical study that there was a marked reduction of infection incidence in laparotomy cases when this antiseptic was used, as contrasted with the cases in which 3½ per cent iodine was used.

The present study was undertaken by the Traumatic Service of Harlem Hospital during the months of October, November and December, 1937, and January, 1938, with regard to the efficacy of alkyl-dimethyl-benzyl ammonium chloride in the care and treatment of injuries. Over 300 cases were treated, but 177 completed cases are presented as a preliminary report. These include:

- A. Skin preparation for the following:
  1. Exploratory laparotomies for penetrating stab wounds and bullet wounds of the abdomen.

\* From the Traumatic Service, Harlem Hospital, New York City.

2. Exploratory operations following stab wounds of the neck.
  3. Removal of foreign body from the neck.
  4. Removal of foreign bodies from the extremities.
  5. Open reduction of fractures of the extremities, with application of Lane plates and insertion of bone graft.
  6. Lacerations of the extremities with repair of nerves, tendons, and vessels.
  7. Repair of lacerations, both superficial and deep, of scalp, face, neck, and extremities.
  8. Amputations of extremities.
- B. Treatment of:
1. Burns.
  2. Infected lacerations, deep infections, and cellulitis.
  3. Avulsions.

A definite routine was adopted with regard to the technique of skin preparation, the type of solution to be used, and the dilutions necessary.

#### WOUNDS

For the disinfection of wounds or traumatic injuries, or as a first aid prophylactic, the tincture, 1:1,000, was used.

For deep lacerations where the application of alcohol should be avoided, the aqueous solution, 1:5,000, was used.

For widely denuded areas, for wet dressings, and for irrigations of deep infections and sinuses, the aqueous solution, 1:5,000, was used.

#### PREOPERATIVE SKIN PREPARATION AND DISINFECTION

*Ward Preparation.* When a patient was prepared on the ward for laparotomy, etc., the field was shaved, washed with water, alcohol, and ether, then with the antiseptic in aqueous solution, 1:1,000, which was allowed to dry.

*Operating Room Preparation.* On the operating table the field was again washed with alcohol and aqueous solution of

zephiran, 1:1,000, alternately two or three times in six to eight minutes. When the patient was draped, the area was painted with the tinted tincture, 1:1,000.

#### PREPARATION FOR OPEN BONE OPERATIONS AND JOINT OPERATIONS

The same preoperative skin preparation was carried out (i.e., with water, alcohol, ether, then with alkyl-dimethyl-benzyl ammonium chloride, aqueous solution, 1:1,000). This preparation was done daily for three days, and then the operating room routine was carried out as stated above.

#### REPAIR OF LACERATIONS

Eighty cases of deep and superficial lacerations of the scalp, face, neck, and extremities were selected for study. Some of these were on the ward because of associated injuries. They varied from superficial scalp and face wounds to deep lacerations of the face, neck, and extremities, of which some were very extensive. The technique was to apply zephiran tincture, 1:1,000, into the wound and to the skin surfaces in the more superficial injuries. In the deep lacerations, we employed a primary irrigation with the aqueous solution, 1:1,000 or 1:5,000, depending upon the extent of the lesion, and painted the skin edges with the tinted tincture, 1:1,000. Some of these wounds were sutured, others approximated with adhesive strips. In only one case, a deep laceration of the forearm, did infection result. In this instance, following removal of the sutures and free irrigation with the aqueous solution, 1:5,000, the infection promptly cleared. The fact that zephiran is not irritating, when used in proper concentrations, and does not damage the healing surfaces makes it particularly efficacious in this type of injury.

#### BURNS

The Harlem Hospital technique in the treatment of burns is a primary debridement, followed by the application of an eschar of tannic acid, followed by 10 per

cent silver nitrate. When this eschar begins to separate, it is gradually debrided. After debridement, the denuded surfaces often become infected from unavoidable contamination. In fifteen cases zephiran aqueous solution, 1:5,000, was applied in wet dressings following the above debridement. There resulted a rapid recession of temperatures from 101 to 103 degrees to normal. Healing then rapidly resulted, first with healthy granulations, then good epithelium. In some of the cases the total skin involved in first, second, and third degree burns varied up to 40 per cent. A solution of 1:10,000 is recommended in infants and children. It is our opinion that the results in burns are striking.

#### AMPUTATIONS

In four cases, middle thigh amputations were done because of gangrene, either of diabetic or arteriosclerotic origin. In all four there was good union at the stump with no subsequent infection. Noteworthy is the fact that these cases fell in the advanced age group.

#### THE ABDOMEN

Through the four months period in which this study was conducted, there were thirty-six patients who required exploratory laparotomy because of penetrating stab and bullet wounds of the abdomen, excluding those in whom death occurred from shock and hemorrhage too immediate to determine any evidence of abdominal wall or intra-abdominal infection. Eighteen of these were prepared by the above mentioned zephiran technique. All were emergency operations. The alternate eighteen received the usual iodine-alcohol technique. No abdominal wall infection resulted in any of the cases, and no intra-abdominal infection could be traced to faulty skin preparation. In both groups, only the patients with bowel perforations contracted peritonitis, a complication which was usually anticipated, but which varied in severity. In six additional cases exploration was done down to the peritoneum but no

penetration was observed. Three of these explorations were carried out under zephiran technique. No abdominal wall infection resulted. In many instances profound hemorrhage, as a result of laceration of the spleen, liver, or the mesentery vessels, often left the patients in a weakened postoperative state, but no abdominal wall infection resulted even in these cases.

#### OPEN BONE OPERATIONS

There were five open bone operations without previous infection or potential infection; this would eliminate the cases of acute osteomyelitis. A large number of cases of compound fractures, especially those of the long bones of the extremities, cannot be considered because studies of a different character are now being carried out by the Traumatic Service on this particular group. Three open reductions of fractures of long bones were done with the zephiran technique.

**CASE I.** In an adult with fracture of the shafts of the radius and ulna, Lane plates were applied; primary union resulted with no evidence of bone infection.

**CASES II AND III.** Two children had open reductions of fractures of the tibia and fibula, with the application of Lane plates to the tibia; both had mild superficial infection. In all fairness, other factors entered. One had poor skin but operation was deemed most necessary. In both instances the operation was performed by teams not by long experience versed in exacting bone technique. This is apt to be the case in a large general hospital with frequent changes in service.

Another patient had a bone graft inserted into the tibia, with primary union and no evidence of bone infection. The last patient had an open operation of the lower end of the humerus, with the removal of badly displaced comminuted fragments. Primary union resulted.

While the authors feel very definitely that the zephiran technique may with every safety be used in open bone operations, a larger series is recommended before this can be proved conclusively.



## THE NECK

Ten cases were explored for possible laceration of the greater vessels. One had a complete severance of the internal jugular vein. The skin was prepared with 1:1,000 tinted tincture. The exploration of necessity invaded the deep fascial planes, but no infection resulted.

CASE I. A deep, self-inflicted 3 inch laceration of the upper anterior surface of the neck, down to and involving the posterior wall of the pharynx. No damage had been done to the great vessels. A tracheotomy was done and the wound repaired with the zephiran technique. No infection resulted.

CASE II. A bullet entered the mouth and lodged in the middle of the neck on the right side in the deep structures. The patient was operated upon one week after injury for removal of the bullet. It was found adjacent to the carotid sheath on the posterior and mesial surfaces. Skin preparation consisted of zephiran technique on the ward and the use of zephiran tinted tincture 1:1,000 at the time of operation. No infection resulted.

## FOREIGN BODIES IN EXTREMITIES

Alkyl-dimethyl-benzyl ammonium chloride was used for skin preparation for the removal of foreign bodies in five cases. All of them were needles, three imbedded in the hand and two in the thigh, one in a 3 months old infant. None of the patients evidenced any postoperative infection and all healed with primary union.

## REPAIRS OF LACERATIONS OF TENDONS, NERVES, AND VESSELS

There were eighteen cases of tendons of the forearm and hand repaired after zephiran preparation. Fifteen of these were discharged to the Out-Patient Clinic at periods varying from four to seven days following admission, with no evidence of infection. Three had mild infection. These three were found to have delayed entry into the hospital, with increasing chance of infection and tendon necrosis. In all the cases the aqueous solution, 1:1,000, was poured into the open wound for its per-

operative germicidal action. The results of this series are to be considered excellent. Three of the above cases had nerve involvement, and repair was accomplished at the same time. In all the cases, vessels were severed, varying in importance, up to the radial artery, and simple ligation was resorted to. There was also a series of eight cases with laceration of the major vessels without tendon involvement, two of these involving the brachial artery. The results of these cases were equally good. There was one case in which the musculospiral nerve was freed from scar tissue. Primary union with no infection resulted.

## INFECTED LACERATIONS, DEEP INFECTIONS, AND CELLULITIS

This group was rather limited, except in cases admitted with neglected lacerations, hand infections, human bites of the fingers, and a few cases of cellulitis of the extremities.

Human bites are a treacherous group of cases and offer no fair test for the germicidal properties of any drug. Infected lacerations responded very nicely to either wet dressings of the aqueous solution, 1:5,000, or with irrigations with this dilution. Its initial use in any infection depends upon the possibilities of irrigation. It was found to be of much benefit in clearing up the infection following free incisions. Deep irrigation with zephiran aqueous solution, 1:5,000, or massive wet dressings with the same dilution, are recommended. Its use in cellulitis comes mostly after incisions for drainage following localization. It is to be noted that no brief is made for this germicide in either hand infection or cellulitis, as an aid towards localization or infection. Hypertonic qualities are not claimed. Its work starts following incisions for drainage. The skin was prepared for incision with the tinted tincture, 1:1,000.

## AVULSIONS

The aim in these cases must be towards the prevention of infection. This calls for

necessary debridement under adequate anesthesia, and the use of drugs of high germicidal potency, to be followed by wet dressings with an antiseptic which will not irritate the denuded surfaces. In four cases, following debridement, tinted tincture of zephiran, 1:1,000, was used and followed by continuous wet dressings of the aqueous solution, 1:5,000, until the danger of infection had passed. The results were very pleasing. Five other cases in which the initial application was not tincture of zephiran also healed nicely under continuous wet dressings of the aqueous solution, 1:5,000.

#### CONCLUSIONS

1. The authors are convinced that alkyl-dimethyl-benzyl ammonium chloride has a very definite place in the germicidal and antiseptic armamentarium for combating infection in injuries. In proper dilutions it does not damage tissue. It thereby enhances the possibility of rapid healing.
2. Its potency is manifested even in the weaker dilutions, and it can be used on large denuded surfaces with comfort to the patient and without toxic effects.

3. Its use in preparation of the skin for operation involving the abdomen and neck, and its use in bone surgery with a minimum of infection, gives some evidence of its high germicidal potency.
4. Its use in burns has given good results in combating secondary infection.

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# CASE REPORTS

## PERSISTENT HEADACHE RESULTING FROM DISPLACEMENT OF THE HEART AND MEDIASTINUM RELIEVED BY PHRENIC INTERRUPTION

REPORT OF A CASE

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THE following case is of interest because of the unusual findings and the apparent value of phrenic interruption in relieving the symptoms.

The patient was a young woman aged 25 years. She complained of severe headaches of about eight years' duration which were becoming progressively worse. The pain would start in the right side of the chest and shoot up the right side of the neck and head. The patient stated that she obtained relief from her pain when lying down but that it returned immediately upon arising.

She had had an operation for appendicitis shortly before the headaches started. There was nothing significant about the operation except that she remembered being in bed a long time and feels that she did not get along well. The headaches were not related to her menstrual periods. The only other significant point in her history was that she had some dyspnea and tachycardia on exertion.

Examination of the patient revealed a well developed and fairly well nourished young woman 5 feet 6 inches tall weighing 120 pounds. Her blood pressure was 110 systolic and 70 diastolic; pulse rate was 86 per minute and temperature was 98.2 F. Her uterus was retroverted but otherwise normal. Examination of the nose and throat showed slight deviation of the septum but no evidence of pathology to explain the headaches.

Roentgenograms of the chest showed the heart and mediastinum to be pulled over to the left. From the fifth rib to the base the lung field demonstrated a homogeneous haziness. The condition was thought to be atelectasis of the left lower lobe. (Fig. 1.)

Because of the marked displacement of the heart and mediastinum a temporary phrenic interruption was done on the left side. With the rise of the left hemidiaphragm the heart and mediastinum returned to a more normal position. (Fig. 2.)

Following the left temporary phrenic interruption the headaches disappeared at once and the dyspnea, which was more pronounced immediately after the phrenic, disappeared in about a month. The patient was examined at monthly intervals, and there was no return of the headaches for six months. She has been perfectly well with the exception of some decrease in appetite as a result of the phrenic interruption.

Between the sixth and the eighth months headaches recurred on three occasions. Fluoroscopic examinations at the end of the seventh and eighth months after the operation showed that the diaphragm was no longer elevated and the function was returning.

Eleven months after the phrenic operation Dr. Schneiders of San Diego was consulted and he reported that the headaches were becoming more frequent and more severe. A bronchoscopic examination showed the left main bronchus to be pulled to the left so that it was difficult to see around it. However, an aspiration probe was passed beyond this point about 3 inches. The deviation was thought to be due to airlessness or atelectasis of the lower lobe.

### COMMENT

A case of severe and persistent headache resulting from displacement of the heart and mediastinum and relieved by phrenic

interruption is reported. It was felt that the lesion was an old atelectasis, probably on the basis of a fibrous stenosis following a

to a more normal position, thus releasing the tension upon the vessels or the sympathetic or vagus nerves.

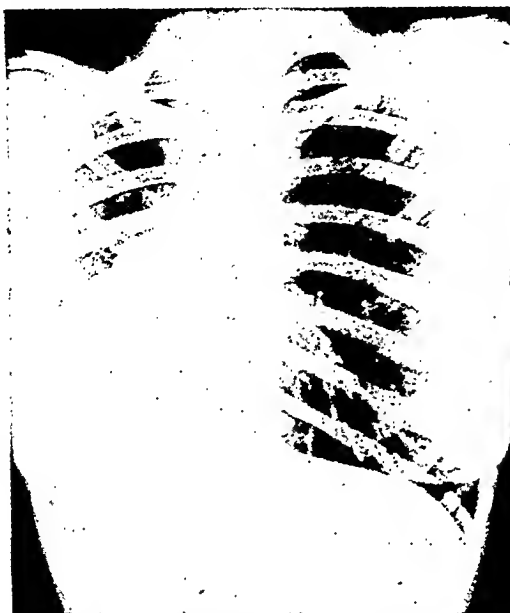


FIG. 1. Roentgenogram of chest before phrenic interruption. Note the displacement of the heart and mediastinum to the left. Also note the displacement of the trachea.



FIG. 2. Roentgenogram of the chest after phrenic interruption. Note the elevation of the left hemidiaphragm. Also note the more normal position of the heart and mediastinum.

pulmonary infection after the appendectomy eight years previous. That the headaches were associated with the intrathoracic lesion was demonstrated by the fact that they disappeared when the left hemidiaphragm was paralyzed and elevated, and that they returned when the function of the diaphragm returned. The elevation of the left hemidiaphragm resulted in some return of the mediastinum

Banyai reported a case in which severe facial neuralgia was relieved by phrenic nerve block. However, the pathology in his case was entirely different in that his patient had advanced pulmonary tuberculosis with diaphragmatic pleurisy.

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# POSTOPERATIVE ABDOMINAL EVISCERATION

## REPORT OF SIX CASES

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THE problem of disruption of postoperative wounds confronts every surgeon who performs a large number of laparatomies. Until recently few writers had reported many of these cases, but of late there have been a considerable number described. As the condition is always serious and carries a high mortality, its early recognition is essential.

A recent experience with a concealed type of evisceration presented a problem the clinical features of which were important enough to warrant careful study, and together with five other personal cases, to prompt the preparation of this report. The details of one case are given in full; the others will be briefly mentioned.

**CASE 1.** H. B., male, aged 57, was admitted to Madison Park Hospital, August 4, 1937, with a complaint of pain in the right lower part of the abdomen, accompanied by vomiting. The preoperative diagnosis was acute suppurative appendicitis.

**Operation.** August 4, under spinal (novocaine) anesthesia, supplemented by gas-oxygen and ether, a right rectus incision was made. The rectus was not split, but retracted laterally. The appendix, 3 inches long, was found in the retrocecal position. The tip was gangrenous and attached retroceally to the posterior surface of the liver. Free fluid but no pus was found within the peritoneal cavity. The appendix was removed in a retrograde manner, the stump cauterized with pure phenol, but not inverted. Closure was performed in separate layers, using plain gut for the peritoneum, chronicized gut for the fascia and silk for the skin. No retention sutures were used. During the closure a small area of the small intestine was accidentally pinched by a clamp. This area was inverted and buried by means of a purse-string suture.

**Postoperative Course.** From August 4 to August 9, the course was uneventful. Temperature, pulse and respiration were normal. On the latter date at 5 P.M. vomiting began and the temperature rose to 102.4°F. Pulse was 120, respiration 20. The patient showed slight distention and complained of epigastric pain. An intravenous injection of 5 per cent glucose was administered, and a complete blood count and chest x-ray were ordered. A blood chemistry was also done. The abdomen was soft, there was no cyanosis of lips or fingertips, and the wound was clean. An enema was effectual.

On August 11, temperature, pulse and respiration were better; white blood count and differential counts were normal; urea nitrogen was 30. The chest x-ray proved negative. The urine was normal and the bowels normal with enemata. The next day the patient complained of slight nausea, but otherwise felt much better.

As a matter of differential diagnosis, the four following conditions were considered (among others) and ruled out: (1) heat stroke; (2) minute pulmonary embolism; (3) partial collapse of the lung; (4) pyelitis (because of burning upon urination).

The wound was clean. A few sutures were removed, and the interior of the superficial part of the wound was examined. There was very poor healing and the edges separated easily. Slight edema was noted. The wound was strapped.

Following another period of distention during the previous night, the wound suddenly burst open on August 14. The intestines were found extruded upon the skin over the abdomen. At 5.15 A.M., the patient was in a condition of partial shock. Secondary operation was performed under gas-oxygen anesthesia. The exposed intestines were bathed with normal saline and replaced. Inspection of wound and peritoneal cavity revealed no pathologic condition except a slough of the fascia and poor healing. The wound was closed by means of through-

and-through sutures of heavy silk. The condition of the patient was poor and evidences of shock were still present. A blood transfusion was given and supportive measures were instituted, but in spite of everything the patient failed to react and died at 8 P.M.

*Query.* Was there a partial or concealed evisceration on August 9 and thereafter?

In retrospect, one is inevitably led to such a conclusion after seeing the disrupted wound. The edges and side of the wound showed practically no evidence of healing. The fascia had not united at all, the edges having sloughed away. In spite of the fact that the intestines did not appear to be strangulated or obstructed, no marks of constriction having been found, the mild syndrome on August 9 was unquestionably that of intestinal obstruction. The institution of Wangensteen suction with marked improvement in all symptoms and the lack of swelling over the wound led us into the belief that an early intestinal obstruction due to adhesions from the appendix stump or elsewhere had been averted.

On August 12, however, eight days post-operative, poor healing was noted after removal of two sutures in the upper part of the wound. Because of this observation the remaining sutures were left in and the wound strapped. On this occasion, had the remaining sutures been boldly removed and a more thorough inspection of the wound made the sloughing fascia and perhaps a tongue of omentum or a loop of gut might have been seen through the parting fascia. At this stage the patient was in excellent condition and such a discovery followed by prompt remedial efforts might have resulted in an entirely different outcome.

**CASE II.** A child of 5 was operated on for acute suppurative appendicitis with perforation and abscess. On the fifth day, following a coughing spell, several loops of gut appeared under the dressing. The child was in partial shock. Under aseptic precautions, the gut was replaced, the wound packed with iodoform gauze and strapped tightly. Recovery followed.

**CASE III.** A female aged 35 was operated on for fibroids (hysterectomy). Her general condition was apparently good, but on the eighth day following the removal of sutures, she became nauseated and vomited shortly after a bowel movement. Examination of the wound showed complete dehiscence with a large tongue of omentum protruding from a partly opened

skin incision. This was returned to the abdomen and the wound packed with a wide thick strip of iodoform gauze and closed except at one end with adhesive. Recovery took place.

**CASE IV.** A ruptured gastric ulcer in a man of 61 was repaired under spinal anesthesia by plication using Pagenstecher linen. Omentum was used to cover the repair of the ulcer. The wound was closed in layers using one Penrose drain. Retention sutures of silkworm gut were used. This patient had marked arteriosclerosis. He was restless and at times seemed delirious. Because of his attempts to get out of bed, sideboards were applied. However, during the night of the twelfth postoperative day, the patient climbed out of bed and collapsed.

Examination showed a ruptured abdominal wound with bowels protruding and lying all over the abdomen. One loop of small intestine (6 inches long) had been almost completely torn off its mesenteric attachment and was adherent in the abdomen to the right side of the incision. It was raggedly torn wide open. The abdomen and intestines were badly soiled. There was very little bleeding. Patient was in shock. Immediate supportive measures were instituted, including blood transfusion. Without anesthesia, a resection and side-to-side intestinal anastomosis after proper cleansing of the operative field were performed. The wound was closed with interrupted heavy through-and-through silk sutures, using two Penrose drains. The patient died thirty-six hours later.

**CASE V.** A ruptured duodenal ulcer in a white man of 32 was given the usual type of repair under spinal anesthesia. Silkworm gut retention sutures were used. Convalescence was uneventful until the fifth day when after a coughing spell patient felt nauseated and thought he "busted" his wound. Examination showed partial rupture of the wound with a loop of gut presenting, adherent to one side. The wound was packed with iodoform gauze and tightly strapped, and the patient recovered.

**CASE VI.** An incisional hernia in a man of 28 had been operated on twice before. Under spinal anesthesia the peritoneum was separately closed with plain catgut followed by a vertical overlap repair using No. 3 chromic gut, with silk for the skin. During the night of the seventh day following removal of the skin sutures, the patient coughed, felt sharp pain in the abdomen and vomited. Examination

showed complete evisceration with several loops of small intestine out on the abdomen. The general condition of the patient was excellent.

Under gas-oxygen ether the abdomen was properly prepared, the intestines replaced and the abdomen closed with through-and-through interrupted double heavy silk sutures. A thick layer of iodoform gauze was placed upon the

2. Only the elderly patients died.
3. Clean wounds ruptured in the young as well as the old.
4. Incomplete evisceration may be very well managed at the bedside if done under suitable precaution.
5. McCauliff<sup>15</sup> found no case of rupture where a muscle-retracting incision was

## SUMMARY

No.	Sex	Age	Operation	Anesthesia	Day of Rupture	Nature	Type of Repair	Remarks
1	Male	54	Appendectomy. No drainage	Spinal with gas and oxygen	14	Complete	Through-and-through silk	Shock, death. Probably incomplete for 4 days. Long operation G. & O. had to be supplemented. Closure difficult
2	Male	5	Appendectomy	Ether	5	Complete	Iodoform packing; gauze strap-ping	Recovery. Closure done in patient's bed.
3	Female	35	Hysterectomy	Gas-oxygen ether	8	Incomplete	Iodoform packing; gauze strap-ping	Recovery
4	Male	61	Laparotomy for ruptured gastric ulcer. Drainage	Spinal	12	Complete	Through-and-through silk; intestinal resection; anastomosis	Death
5	Male	32	Laparotomy for ruptured duodenal ulcer. Drainage	Spinal	5	Partial	Gauze and strap-ping	Recovery
6	Male	28	Incisional hernia	Spinal	7	Complete	Gauze and through-and-through silk	Recovery. Sutures out on fourteenth day.

abdominal contents just under the closure and allowed to come out at one end. This was removed in stages after the seventh day. The sutures were removed, a few at a time after the twelfth day. Recovery was uneventful.

## COMMENTS

While this series is too small to form any definite conclusion, there are, nevertheless, several points of interest:

1. Mortality, two out of six cases, or 33 $\frac{1}{3}$  per cent.

used. Case 1 in this series had this type of incision.

6. Alert, careful investigation of sudden changes in progress after operation may result in early recognition of impending, partial or concealed rupture. In such early recognition lies the hope and reward of a happy outcome.

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# PULMONARY TUBERCULOSIS IN A CHILD

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THE case of a young Portuguese boy is presented here, not only because of its unusual character, but because in a brief span of life he has passed through the entire cycle of a dreaded disease. He has emerged for the present with the disease arrested, aided by modern therapeutic procedures. The prognosis is still problematical and time alone will tell the ultimate result. Because he has run the complete course from the pathogenic, diagnostic, and therapeutic viewpoints, he has offered at various times cross-sections of practically all stages and types. The illustrations offer the best medium for conveying this chronologic presentation.

## CASE REPORT

On May 10, 1933, a 6 year old child, who had been born in Portugal, was referred to the lung clinic of the Babies' Hospital. There was a strong familial history of tuberculosis and the contact was both intimate and prolonged.

The child complained chiefly of cough, mucopurulent expectoration, and afternoon fever of several weeks' duration. Two months before the above syndrome, easy fatigability and malaise were noted by the grandmother. Anorexia and night sweats were more recent disturbances.

Physical examination revealed a slightly undernourished youngster, appearing somewhat chronically ill, and weighing 39 pounds. Beyond slightly infected tonsils, and poor teeth, positive findings were confined to the lung. Over the upper and mid-portions of the right lower lobe there were dulness, bronchovesicular breath sounds and constant medium inspiratory râles, persistent after cough. D'Espine's sign was negative.

An x-ray taken in April 1933, two weeks before admission, showed bilateral lesion of hilar adenopathy. (Fig. 1.) The process was

somewhat more marked on the left side, and the diagnosis of primary infection was made. The Mantoux test—old tuberculin, dilution 1-1,000—was positive and gave a three plus reading.

Another x-ray, taken at the clinic of the Babies' Hospital, May 10, 1933, showed a remarkable change in the elapsed month. (Fig. 2.) The left hilar region seemed to be clearing and on the right side in the mid-zone extending from the hilum there was an extensive parenchymal process with a cavity whose diameter measured 2.5 cm.

A diagnosis of both primary type of infection and so-called adult tuberculosis (cavity formation) was made. The transition was so rapid that both phases could be noted at the same time. Hospitalization was advised with the thought of instituting collapse therapy.

On May 24, the patient was admitted to the hospital, and additional laboratory data instituted. His urine and blood counts were within normal range. Gastric contents, stools and a laryngeal smear all showed an abundance of tubercle bacilli.

Artificial pneumothorax was begun May 26, 1933. The average refill was 200 c.c., and treatment was repeated two or three times weekly. Collapse took place and the cavity became well defined. (Fig. 3.) About two months after the first artificial pneumothorax, the lung was collapsed to about 75 per cent and the cavity could be visualized as much smaller. (Fig. 4.) The mediastinum was pushed toward the contralateral side and a so-called mediastinal hernia could be detected.

It was decided to proceed with extreme caution. The question arose as to whether to insert some foreign substance, such as sterile mineral oil, into the pleural cavity in order to lend greater stability to the mediastinum. The boy was always difficult to handle, but at this stage he became more unruly than ever. Because he was so ungovernable, isolation was difficult and imperfect, and contamination of other small

children in the ward was feared. On July 31, 1933 he was therefore discharged to Glen Gardner Sanitarium, where better supervision

New Jersey. His sputum was positive for tubercle bacilli, his urine was negative, and blood Wassermann and Kahn tests were also



FIG. 1. April 1933. Bilateral hilar adenopathy, especially left.



FIG. 2. May 10, 1933. Left hilar adenopathy clearing. Extension into parenchyma of lung at right mid-zone with cavitation.

and isolation could be maintained. Refills were given twice a week with great difficulty because of the child's temperament. Sedatives were of no avail and general anesthesia was the only possible way to maintain the pneumothorax. However, this was decided against, and artificial pneumothorax was abandoned because of the lack of coöperation. The patient continued to run a low grade temperature and to expectorate tubercle bacilli.

negative. The blood count revealed 14,000 white cells, with 70 per cent polymorphonuclear cells, 29 per cent lymphocytes, and 1 per cent eosinophiles. Figure 3 represents the x-ray taken at that time. There was a slight rise of the right diaphragm as compared with previous films. At the site of the original lesion there was still infiltration and rarefaction suggesting the



FIG. 3. May 15, 1933. Artificial pneumothorax instituted on right side. Cavity now well defined.



FIG. 4. July 1933. Pneumothorax has effected a 75 per cent collapse. Mediastinal hernia on left side with general shift of mediastinum. Cavity much smaller.

On October 17, a right phrenic nerve resection was performed. The diaphragm rose to nearly one interspace, but this had only a very slight beneficial effect upon the pathology.

The boy remained at the institution for about one year, during which there was a gain of 4 pounds. He did not run any temperature, but his sputum remained positive.

On July 18, 1934, he was admitted to the Essex County Isolation Hospital in Belleville,

cavity. In the left upper lobe a recent exudate spread could be noted. The sedimentation rate averaged 80 (Westergren method), and the temperature fluctuated between 99 and 100.5 degrees.

The child was maintained on the usual sanitarium régime of an active tuberculous case. An x-ray taken six months later (January 14,

1935) again showed the remarkable tendency to clear and spread. (Fig. 6.) Resolution and fibrosis were starting to take place on the left

tion continued and his general condition seemed slightly worse, he was sent back for further care.

On his readmission there was no essential

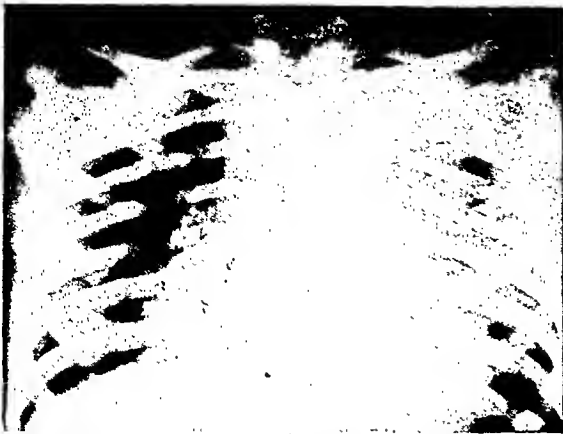


FIG. 5. July 18, 1934. Slight rise of right diaphragm following phrenicectomy. Fibrosis at site of original lesion. A new exudate spread of left upper lobe.



FIG. 6. January 4, 1935. Resolution and fibrosis taking place in left upper lobe. A new lesion is forming in second anterior interspace on right.

side and the original focus on the right side revealed fibrosis and possibly an ill defined cavity. However, in the second anterior interspace, a new lesion was forming.

A few months afterward, he started to reveal definite signs in the right upper lobe and his sputum became more profuse. An extensive lesion of the right upper lobe with cavity

change in laboratory work-up from his first admission to Essex County Isolation Hospital. An attempt was made to start pneumothorax again, but this met with persistent failure, for the pleura was now completely adherent. At this time thoracoplasty was suggested in spite of the child's age, since no alternative could be offered. We decided to observe the left side for



FIG. 7. May 16, 1935. New lesion in right upper lobe is becoming more extensive and cavitation taking place.



FIG. 8. May 29, 1936. Lesion still active in right upper lobe. Left side fairly clear.

formation was noted in an x-ray taken May 16. (Fig. 7.) The original lesion seemed to be undergoing fibrosis, while the left side continued to clear with fibrosis and calcific deposition as residue.

The uncoöperative guardian now stepped into the picture and removed the child to her home, where he remained from May 29 to December 5, 1935. Since cough and expectora-

tion continued and his general condition seemed slightly worse, he was sent back for further care.

On his readmission there was no essential change in laboratory work-up from his first admission to Essex County Isolation Hospital. An attempt was made to start pneumothorax again, but this met with persistent failure, for the pleura was now completely adherent. At this time thoracoplasty was suggested in spite of the child's age, since no alternative could be offered. We decided to observe the left side for

several more months and then proceed with surgery. The left side was considered satisfactory both from a clinical and a roentgenologic viewpoint on May 29. (Fig. 8.) A two-stage thoracoplasty was then performed by one of us (R. H. D.).

*Technique and Course.* First stage thoracoplasty was done June 22, 1936 under avertin, nitrous oxide and oxygen anesthesia. The first,

second and third ribs were resected, and the first removed to the costocartilage. Smaller sections than usual were removed from the



FIG. 9. October 1936. After first stage thoracoplasty. Three upper ribs removed.

second and third. This was done for a two-fold purpose: (1) it was thought that on account of the age of the patient, the bony cage would be more yielding and good collapse obtained with less sacrifice of support; and (2) we hoped that there would be less tendency to spinal deformity. The wound was closed in layers and a Penrose drain inserted. The duration of the

On October 23, a second stage thoracoplasty was done under the same anesthesia as the first. The fourth, fifth and sixth ribs were resected, and a revision of the second and third was done. Closure was done without drainage. The patient stood the procedure well and convalescence was uneventful. The wound was clean. A Bucky roentgenogram, taken in February 1937, demonstrated collapse and beginning spinal deformity. (Fig. 10.)

In a child so young one would naturally expect some postoperative spinal deformity, and for this reason the resections were less extensive. A spinal fusion at the time of operation has been suggested and performed by Dr. Coryllos. Of late Dr. Coryllos has been using a rib graft,<sup>1</sup> and this would probably have obviated the spinal curvature, but at the time we were not familiar with the procedure. No attempt was made to free the lobe as in the Semb operation,<sup>2</sup> because in one so young it was felt that the mediastinal structures would be unduly yielding and too much of a shift obtained.

At present the patient is doing very well. He is maintained on a modified sanitarium régime with very little liberty. The fear of deformity of the spine has always been present and the



FIG. 10. February 1937. After second stage thoracoplasty. Fourth, fifth and sixth ribs removed. Bucky x-ray also reveals beginning spinal deformity.



FIG. 11. November 1936. Photograph of child taken one month after second stage thoracoplasty.

operation was fifty minutes, the patient's condition remaining good

The postoperative course was uneventful, the highest temperature being 101. Slight serous drainage took place from the wound. The left side was relatively clear in October, after the first stage had been completed. (Fig. 10.)

orthopedic service is taking care of this phase of a special brace. His general condition has improved considerably, his appetite has increased and mentally he seems happier.

It is interesting to note that the sputum has diminished and is negligible in quantity. On the second admission to Essex County Isolation

Hospital the sputum was positive and remained so fairly consistently until the first stage thoracoplasty. After this only an occasional positive was noted. Since the second stage thoracoplasty in October 1936, no positive sputum has been detected.

The sedimentation rate also is worthy of noted. The Westergren method, where a high normal is considered 25, was utilized. In the first thoracoplasty the rate was 83. After second stage thoracoplasty the rate was 67. In

objectionable. The phrenicectomy which followed in this case was of little value.

This child, age 9, is the youngest instance of thoracoplasty in tuberculosis that we could uncover in the literature. Fishberg<sup>6</sup> states that Maurice Davis performed thoracoplasty for bronchiectasis in children 3½, 5 and 7 years old, and in one case of tuberculosis in a child of 12 years. He was unable to encounter one instance of opera-

TABLE I  
GENERAL PICTURE 1933-1937

	Incomplete Pneumo- thorax 1933	Phrenicectomy 1934	1935	After First Thoracoplasty 1936	After Second Operation 1937
Sedimentation rate (Westergren).....	.....	.....	83	67	18-25
Bacilli } .....	Positive	Positive	Positive	Occasional positive	Negative
Sputum Amount } .....	Abundant	Moderate	Moderate	Diminished	None
Temperature.....	99-101	99-101	99-100	99-100	98-99
Weight.....	39 pounds	41½ pounds	50 pounds	61 pounds	68 pounds
Toxic Symptoms.....	Present	Present	Present	Diminished	Absent

December 1936, the rate was 25, and in February 1937, the rate was 18.

The general trend of improvement in every direction, corroborated by laboratory data and roentgenograms is very gratifying. (Table I.)

#### COMMENT

This child was quite young when artificial pneumothorax was instituted, but younger cases have been reported. Gardere and Wenger,<sup>3</sup> after a study covering over twenty years, believe that the procedure is beneficial in ulcerocaseous forms of tuberculosis in children, but admit only a 20 per cent satisfactory and lasting result. Gross and English<sup>4</sup> state that whenever artificial pneumothorax could be adequately employed, the results were far superior to any other type of compression. This is in accord with our opinion and it is therefore regrettable that refills could not be given. G. Zederbauer<sup>5</sup> states that avertin anesthesia may be given in very young or excitable children, but this was considered

tion being performed for tuberculosis in a child under 12 years of age. According to Alexander,<sup>7</sup> thoracoplasty should be limited to patients between the ages of 15 and 45. In 1913, Sauerbruch<sup>8</sup> cited Lenhartz as performing a complete operation in a child of 12. Jacobaeus and Key<sup>9</sup> report bad results in patients less than 20 years of age and state that surgeons are hesitant to perform thoracoplasty, but they believe that some children should have the benefit of this procedure.

The fact that the collapse effected by the thoracoplasty is not as great as usually desired, is appreciated. It is realized that we were too cautious and conservative, but the opportunity to perform this type of surgery in one so young is rare. It is suggested that in the future a greater portion of each rib may be removed. The follow-up of this case is rather brief (ten months) and therefore, no conclusions can be definitely outlined. The possibility of reactivation and future revision procedures is not

unlikely. Despite the several unfavorable authoritative opinions voiced on the eventual outcome of this case, we offer it as a preliminary report and hope to review its progress in the next few years.

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REGENERATION does occur with certain human tissue and under certain circumstances. The liver, for example, regenerates perfectly even when almost all of it has been removed, and so do some other parenchymatous organs, but to a lesser extent.

# NON-CASEOUS TUBERCULOSIS OF THE THYROID GLAND

## REPORT OF A CASE

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AND

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**T**UBERCULOSIS of the thyroid gland, though rare, occurs more frequently than was once thought. Careful microscopic study of resected thyroid tissue probably accounts for the apparent increase in incidence.

Rankin and Graham reported a group of cases several years ago, a large percentage of which presented symptoms of hyperthyroidism and were found to have high basal metabolic rates. Microscopic examination of the gland revealed the structure typical of exophthalmic goiter associated with the tuberculous involvement in many cases. Usually tubercles and giant cells were seen. A few cases of tuberculous thyroiditis unassociated with adenomas and hypertrophic changes were found. No pulmonary tuberculosis was found in any of these cases, and the original focus could not be determined; the authors concluded that it was too small to find. However, it seemed logical that the thyroid gland was invaded secondarily, probably as a result of tuberculous bacillemia. Van Ravenswaay and van Ravenswaay concur with Rankin and Graham that a diagnosis can be made from the microscopic picture with a high degree of accuracy. Most writers disagree with Cohen who stated that the diagnosis should be made clinically.

### CASE REPORT

A 60 year old white woman was seen July 29, 1937. She complained of a lump in the right side of her neck, which she had first noticed about six months before. It had gradually increased in size since that time.

She had been hoarse since 1904, but the degree of hoarseness varied from time to time. She had always been thin and had frequent

colds with a great deal of sputum. A pelvic tumor was removed in 1916. She had been told that she had pulmonary tuberculosis in 1920, but had taken no treatment. In 1923 another examination revealed "pulmonary tuberculosis with many cavities" and "heart trouble." However, she went on teaching school.

She had been told that the deaths of two of her sisters, each at the age of 23 years, had been due to tuberculosis, but she had not lived with them for several years prior to their deaths.

Examination revealed the patient to be underweight by about 20 pounds. Her temperature was 98.6; pulse 100; blood pressure 150/100. There were no eye signs indicative of exophthalmic goiter. The larynx and vocal cords were normal. The right lobe of the thyroid gland was enlarged and very hard, and seemed to be attached to the thyroid cartilage. The heart was normal and there were harsh breath sounds present over both apices. The abdomen was negative except for a low midline scar. Pelvic examination was essentially negative. X-ray of the chest showed, old fibrotic changes in both apices and at the left costophrenic angle. No areas of soft tissue infiltration suggestive of active tuberculosis were detected in the lung fields. The density of the lung fields suggested an emphysematous condition. Blood studies showed hemoglobin 89 per cent, 4,120,000 red blood cells, 4,850 white blood cells, 78 per cent polymorphonuclear leukocytes, 19 per cent small lymphocytes, 3 per cent large lymphocytes. An uncatheterized urine specimen contained an occasional pus cell. The basal metabolic rate was minus 9.

A diagnosis of adenomatous goiter without hyperthyroidism was made. It was felt that the adenoma had probably become malignant.

On August 2, under local and gas anesthesia, the entire right lobe, isthmus and one-half of the left lobe were resected. The right lobe was very adherent to the muscles and trachea. The



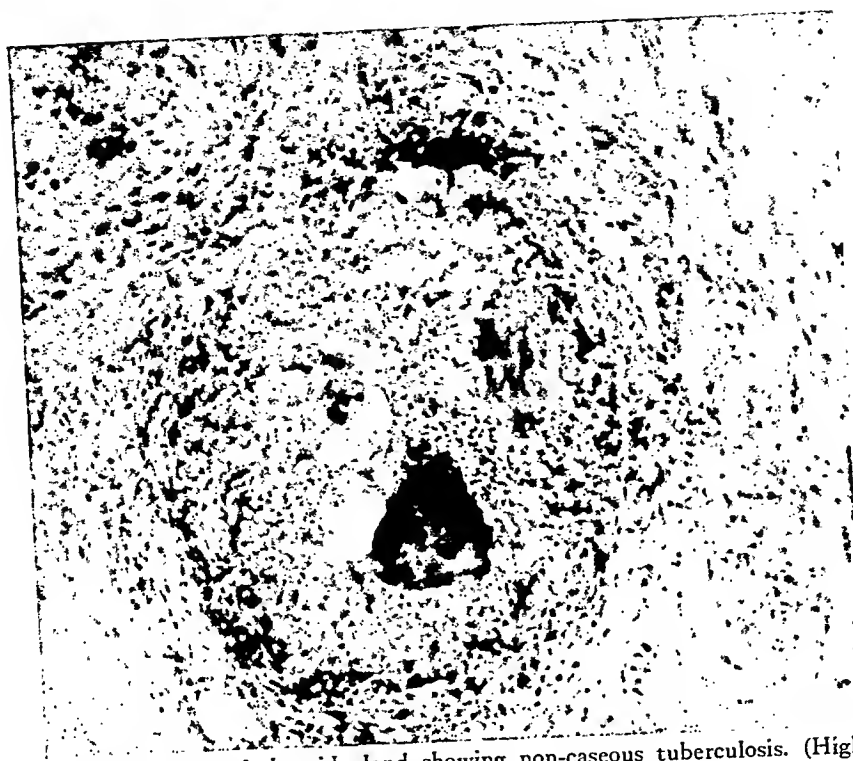


FIG. 1. Section of thyroid gland showing non-caseous tuberculosis. (High power.)

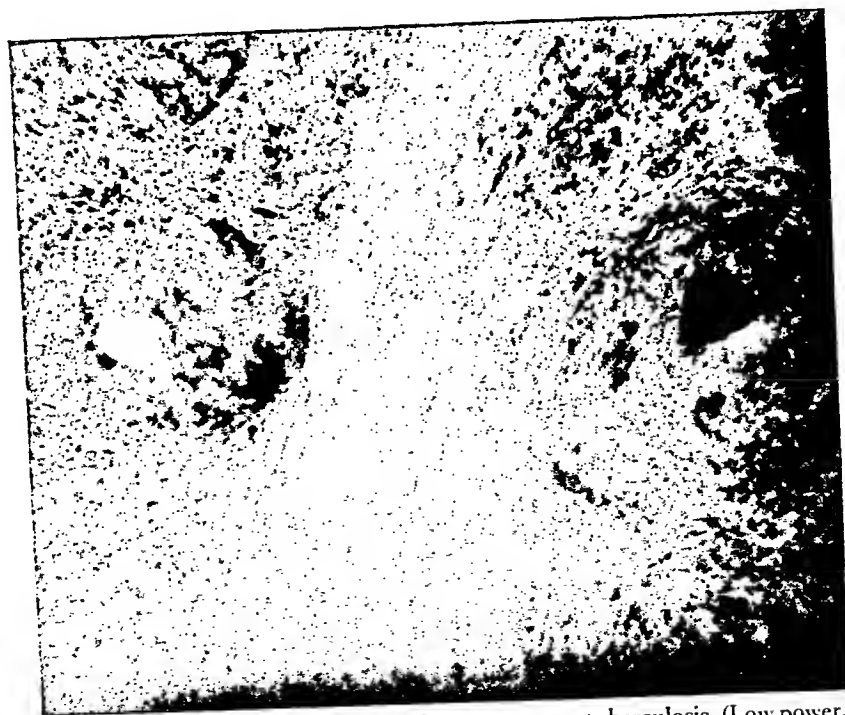


FIG. 2. Section of thyroid gland showing non-caseous tuberculosis. (Low power.)

resected thyroid tissue measured  $5 \times 4 \times 3$  cm. and grossly was grayish-white in color and very firm in consistency. The microscopic sections showed a diffuse non-caseous tuberculosis.

The immediate postoperative course was uneventful. The wound healed promptly, but the hoarseness has persisted as before though there is normal movement of the vocal cords.

This case is of unusual interest in that it gives a more definite clue to the primary site of infection than most others reported. Two and one-half months following operation symptoms of a mild hypothyroidism developed and the basal metabolic rate was found to be minus 16. Administration of desiccated thyroid gr. 1 daily brought the rate up to normal and since that time  $\frac{1}{2}$  gr. daily suffices. The patient feels well and carries on her regular teaching duties.

#### CONCLUSIONS

1. Tuberculosis of the thyroid is rare.
2. Most cases have associated hyperthyroidism.
3. The diagnosis is almost never made clinically.
4. The prognosis is usually good.
5. The case presented is of unusual interest in that it gives a more definite clue to the primary site of infection than most others reported. The pulmonary tuberculosis has apparently healed. There has never been any evidence of laryngeal tuberculosis. There was no hyperthyroidism. The wound healed readily without prolonged drainage. With the exception of

a mild hypofunction of the remaining portion of thyroid tissue, which is easily controlled by the administration of desic-

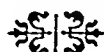


FIG. 3. Recent roentgenogram of chest showing fibrosis in both bases and no evidence of active tuberculosis in the apices.

cated thyroid, the patient is in good health.

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# THREE CASES OF CONGENITAL UMBILICAL HERNIA\*

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TO find the cause of congenital umbilical hernia we have to go back to the early weeks of embryonic life. At this time the primitive alimentary tract is divided into three main subdivisions—the foregut, the midgut and the hindgut. At about the fifth week of life the midgut is pushed out through the umbilicus and there is a physiologic umbilical hernia, due to the rapid increase in the length of the midgut and the marked increase in the size of the liver. The growth of these two organs is out of proportion to the growth of the rest of the abdomen, and the abdominal cavity is not large enough for all the structures. Between the second and third month of embryonic life it is perfectly normal for this midgut loop to develop within the umbilical sac.

About the tenth week of life the alimentary tract begins to go through the second stage of rotation, and this traction on the loops of bowel usually results in the return of the midgut section of the abdomen. Failure of withdrawal at this time is now generally thought to be the primary cause of congenital umbilical hernia. The intervention of these organs which should have receded into the abdominal cavity prevents the proper approximation of the abdominal muscles on the two sides at the midline. Instead of the umbilical cord emerging from a small opening there is really no umbilicus—only a large oval-shaped defect in the midpart of the abdominal wall through which the viscera protrude into the umbilical cord. The protruding mass may be large or small intestine or both. The liver is frequently within the mass and the spleen may also be within it.

*Incidence.* Congenital umbilical hernia is an extremely rare finding. According to Jarcho, not more than 356 cases have been reported in the literature. He points out that there must have been many cases in stillborn infants or in those who died shortly after birth, which have never been reported.

*Diagnosis.* The diagnosis presents no difficulty. It is self-evident as soon as the child is delivered. The hernial sac is often translucent and the contained viscera can easily be seen through it.

*CASE 1.* A baby girl was born August 25, 1935 after a normal labor. Delivery was spontaneous. The child weighed 6 pounds 2 ounces. There was a tense mass the size of a baseball in the umbilical region, covered by a thin serous membrane through which could be seen loops of intestine. It was impossible to reduce the mass and it was easy to see that any great amount of pressure would rupture the covering membrane.

Operation was performed just three hours after birth under chloroform-ether and oxygen anesthesia. The sac was opened and found to contain about one-half the small intestine, the appendix, the ascending colon, and part of the transverse colon. The loops of bowel, which were adherent to the sac, were freed by sharp dissection and returned to the abdomen. There was some difficulty in this, as the abdominal cavity was not used to containing such a large mass of organs. The sac was trimmed flush to the edges of the abdominal wall and all vessels were ligated. No attempt was made to separate the layers of the abdominal wall. The abdomen was closed with interrupted through and through black silk sutures. The time of operation was twenty-two minutes.

A clysis of 75 c.c. of normal saline was given. The temperature that evening was 104.8, but came down the next day and remained down.

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The wound healed by primary union. The baby was discharged twenty-five days after operation, at which time she weighed 6 pounds and 15 ounces—a gain of 13 ounces over the birth weight.

In spite of the uneventful postoperative course the child showed certain signs of mongolism. There was a heavy pad of fat at the base of the neck, the fontanelles did not close on time, and the child was very susceptible to every infection. It died at four months of age of lobar pneumonia. The father and mother were both normal and healthy. There were two other children, 11 and 14 years of age, both normal and healthy.

**CASE II.** This male infant was born September 15, 1935. Labor was normal and delivery spontaneous. Weight was 7 pounds and 4 ounces. In this case there was a large, dark-colored, oval-shaped mass in the umbilical region. Our belief that it contained liver proved to be correct.

The baby was operated on a little less than three hours after birth. A few drops of chloroform were used. The lower part of the sac was opened and the contents explored. There was no bowel in the sac but the whole anterior half of the liver was firmly adherent to its upper part. It was just as if the peritoneum covering the anterior surface of the liver were directly continuous with the skin on either side of the abdomen. We saw that it would be impossible to free the sac from the anterior surface of the liver—it would be just like trying to dissect the peritoneum off the liver, since this one layer of tissue was in reality both the peritoneal covering of the liver and the outer or skin covering of the abdominal wall at this point. We trimmed the sac away from the edges of the abdominal wall on either side and then cut it away from the liver all the way around at the point where the sac became adherent to the liver. We had to leave the center of the sac permanently attached to the anterior surface of the liver. We then returned the liver to the abdomen and approximated the two sides of the abdominal wall with interrupted through and through black silk sutures. The defect in the abdominal wall was about 4 inches in length. The time of operation was twenty-one minutes.

Our great fear in this case was that there would be peritonitis from the anterior surface of the liver which had served as a skin covering to this part of the abdominal wall. However,

nothing happened. We gave the baby 40 c.c. of his father's blood. He made an uneventful recovery and was discharged on the fourteenth



FIG. 1. Case III.

day, when his weight was 7 pounds and 10 ounces, a gain of 6 ounces over the birth weight. I saw the child again when he was a little over 2 years of age and weighed 24 pounds. He is healthy, active, and intelligent, but I do not think he is quite as sturdy as the other children in this family. Both parents are normal and healthy. There are four other children, one born after this baby. All are normal.

**CASE III.** Baby girl, born February 11, 1938, was a first child and full term. The labor was normal and the delivery spontaneous. The weight was 6 pounds and 3 ounces. In this case there was a tense mass the size of a small grapefruit occupying the center portion of the abdomen and covered by a thin membrane through which could be seen the liver and the coils of intestine. The cord was tied off to the left side of the sac.

The baby was operated on one and one-half hours after birth under chloroform, ether, and oxygen anesthesia. The sac was opened and explored. It contained the liver, spleen, ascend-

ing colon, transverse colon, and the small intestine. Almost all the viscera with the exception of the stomach and the descending colon were out of the abdomen and in the sac. There were many fine adhesions between the sac and contents, but these were freed easily by finger dissection. The sac was then trimmed away all around at the skin margin.

It was very evident at the start that it would be a most difficult, if not impossible, task to return all these organs to the abdomen, since the abdominal cavity had not developed in size with the organs. The fact that these organs had been outside the abdomen for so many months meant that there had not been sufficient stimulation for the proper enlargement of the abdomen. Their return required considerable manipulation and much unavoidable pressure. The wound was closed with through and through black silk retention sutures. The lower part of the wound was rather tense and it was evident that there was considerable pressure on the contained viscera. It seemed rather doubtful that they could adjust themselves to this pressure.

The baby was given 40 c.c. of father's blood in the muscles and this was repeated on subsequent days. Clyses of normal saline with 5 per cent glucose were also given at frequent intervals. A karo mixture was given by mouth, but very little of this was retained. There was some vomiting of dark bloody material from the start. The baby had two to three bowel movements every day and these appeared to contain blood. The rapid respiration and cyanosis which persisted from the time of operation were very striking. There was apparently tremendous

pressure exerted against the diaphragm. The temperature was 98.6 the day following operation, but rose to 102.4 twenty-four hours later and remained up. It was evident from the beginning that this baby would not survive. The vomiting was frequent, the respirations fast, and the cyanosis marked. The baby died three days following operation. Autopsy was refused.

*Treatment.* Every case of congenital umbilical hernia should be operated on immediately, provided surgical means are available. The sac should be incised, the contents freed from the sac and reduced, and the abdominal wall closed. The operation should be done at once even though the contents of the sac can be reduced. Delay results in desiccation of the sac and the possibility of its being torn. If desiccation results, it is almost sure to be followed by infection and peritonitis.

#### CONCLUSION

The three cases presented here demonstrate that the operation for congenital umbilical hernia may be either a relatively simple procedure or an extremely difficult one with little chance of success. It all depends on how much of the gastrointestinal tract is in the sac and has to be returned to the abdomen. In any event, the earlier the operation is performed the greater are the chances of success. Babies seem to stand the operative shock very well.



# PARAFFINOMA OF MALE BREAST\*

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THE injection of melted paraffin to correct disfigurements, defects, impaired physiologic function and certain other pathologic conditions seemed to be a relatively simple and satisfactory operation when first advocated thirty-eight years ago. At that time Gersuny recommended the injection of paraffin of low melting point to correct depressed scars, and the method was received with enthusiasm. Pure paraffin ( $C_{27}H_{56}$ ) was thought to be a harmless and indifferent material which would be tolerated by the body organism and afford permanent results. Gersuny also recommended it as a means of correcting certain speech defects by injecting the paraffin into the soft palate and uvula. At the time it appeared to be an effective procedure, as, indeed, it proved to be one of the simplest.

With happy optimism, saddle nose, pendulous breasts and various facial defects were corrected with the pliable paraffin to the utmost satisfaction of the patient.

The injections of paraffin at low melting point— $40^{\circ}\text{C}$ . ( $104^{\circ}\text{F}$ .)—were used not only as an aid to cosmetic surgery, to correct depressions and wrinkles, but were also recommended in the character of prothesis. Surgeons claimed excellent results in cases of urinary incontinence, anal prolapse and even hernia. In ozena, paraffin was used as a trophic stimulant. Voice defects were corrected in paralysis of the vocal cords by paraffin injection. It was even used in abdominal surgery to prevent adhesions.

But reports of complications began to appear in the literature. Emboli occurring after paraffin injections brought the practice into disrepute. Kofman was unfortunate enough to see one of his patients die of

pulmonary embolism after a cosmetic operation. Complaints were made that the injected paraffin became displaced, producing additional disfigurements and necessitating operative intervention for its removal. In certain instances paraffin injected into the cheeks migrated downward over the jaw and produced serious disfigurement (Sehrt; Wassermann).

Eckstein claimed that emboli could be prevented by injecting paraffin of a higher melting point ( $58^{\circ}\text{C}$ .) and believed that these complications were merely due to the use of paraffin of low melting point. His recommendation was gladly accepted and the technique was modified by the use of a high pressure injection machine. This method was largely practiced in the field of cosmetic surgery until numerous late complications were reported.

Sehrt observed a case in which surgery was necessary to remove the paraffin together with the adjacent chronically inflamed tissue, and Benedek demonstrated that paraffin injected into a patient's breasts gave rise to a chronic productive inflammation thirteen years later. He called the condition paraffinoma. In this case both breasts, which had previously been injected for cosmetic purposes, were operated upon because the condition simulated malignant disease. Paraffinomas of the breast developing from two to twenty years after the injections were reported by others. In Rose's case both breasts had to be amputated eighteen years after paraffin injections had been used for cosmetic purposes.

During the World War malingerers had paraffin injected into their tissues so as to create artificial tumors which would enable them to escape military service. Flandin

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observed a paraffinoma of the instep following an injection nineteen years earlier. Fischer-Wassel described a case of fatal



FIG. 1. Ulcerated paraffinoma of the male breast.

cirrhosis of the lung after protracted use of nasal menthol oil applications. Jaffa reported a case in which the administration of paraffin oil by mouth might have been the cause of an appendicitis. It is, of course, questionable whether the paraffin found in the appendix was the cause of the appendicitis or whether it had lodged in the appendix because of that organ's pathologic condition.

Whittaker observed ulceration in the bladder following paraffin injection for hernia.

During the period when oleothorax was used, numerous observations of paraffinomas of the thoracic wall were described.

A few typical adenocarcinomas were found in breast previously subjected to paraffin injections for cosmetic purposes. Despite this finding there is no proof (though a constant chronic irritation might be considered the underlying cause of the development of the cancer) that the paraffin is the cause of the cancer, and in view of the relative frequency of cancer of the breast it may be regarded as mere coincidence.

Pathologically, paraffin injections result in foreign body granulomas with no tendency to malignancy. Bolam, Weidman, Jaffa and others observed that such paraffin forms a localized tumor and, as Baer

pointed out, the deformities may develop within six months to five years later. It is of more than passing interest that the injection of vegetable oils shows no tendency to tumor formation. Paraffin acts as a foreign body and the resulting irritation produces a benign granuloma which is not a true neoplasm (Weidman). Flandin and others have claimed success with x-ray treatment of such small granulomas beneath the eyelid, thus obviating surgical interference. There was, however, no proper follow-up of the case reported. In our own case which is unique in the available literature we have observed this as a wandering of the paraffin to the regional lymph nodes accompanied by secondary inflammation. No lymph node involvement was noted by other reports.

#### CASE REPORT\*

W. S., an actor, a white male of 34, and single, was referred to our clinic from Florida with the diagnosis of possible cancer of the right breast.

He stated that four years previously he had been troubled with "contractions and a throbbing sensation" in his right breast for which condition he received various forms of physiotherapy, including x-ray, in Paris, and that about two years before, a physician there had injected some kind of fluid into the breast without effect. About two months before examination the patient noticed that an area in the right breast was becoming red and slightly painful. This opened and discharged some serous fluid. About this time he noticed a lump in the right axilla and consulted his physician in Miami who advised him to come to our clinic. The family history was irrelevant.

The face was asymmetrical. The right side was drawn upward, showing definite contraction over the mid-portion of the right mandible. Numerous small dilated blood vessels were present in this region. The right side of the neck extending downward to the chest and into the upper and lower arm on the outside surface presented telangiectasia, probably as the result of previous x-ray treatments.

\* For analysis of male breast tumors see CHOLNOKY, TIBOR DE. Benign fibrous tumors of the male breast. *Am. J. Surg.*, 30: 298; 309; 396, 1935. Benign tumors of the breast. *Arch. Surg.*, 38: 79-98, 1939.



The right breast was involved by an ulcerative process approximately 2 inches in diameter which had entirely destroyed the nipple and

tory mastitis and a diagnosis of paraffinoma was made. The indurated and ulcerated inflammatory areas were circumscribed by the electric



FIG. 2. Low power section showing cystic spaces in derma with inflammatory infiltration of surrounding stroma.



FIG. 3. High power view of inflammatory changes in stroma showing foreign body giant cells. The cystic spaces show no epithelial lining.

was surrounded by a bluish red area extending over the whole breast toward the sternum and axilla. The mass was rather firm and there were stony hard infiltrations over the surrounding inflamed areas. The entire lesion was slightly tender and unattached to the underlying tissues, that is, it did not seem to be adherent to the pectoral fascia or muscle. There were several large and slightly tender lymph nodes in the right axilla. The other breast was normal.

The Wassermann reaction was negative. Urinalysis was negative. The blood showed a mild secondary anemia.

A clinical diagnosis of ulcerated tumor, possibly carcinoma of the right breast was made, but the possibility of a chronic inflammatory condition caused by previous paraffin injections had to be kept in mind. The patient was advised to enter the hospital for an operation, which was performed March 5, 1932. A biopsy specimen was secured with an electric loop. During this procedure a soft white material, recognized as paraffin, ran out of the wound. Frozen section confirmed the diagnosis of a chronic inflamma-

cutting blade and resected en masse. Pieces of paraffin vaying from 1 mm. to 1 cm. in diameter were found distributed in the subcutaneous fatty tissues. All indurated fatty tissue between the skin and pectoral fascia was removed. The skin and pectoral fascia did not seem to be involved in the process. The enlarged axillary nodes were carefully removed. After hemostasis a rubber drain was inserted and the skin was united with interrupted black silk sutures. The wound healed normally.

Pathologic examination was done by Dr. D. S. D. Jessup, pathologist of the tumor clinic, and the report may be quoted as follows: "The section shows fibrous tissue with enlarged cystic glands and inflammatory infiltration giving the appearance of a cystic mastitis without epithelial lining of the cystic spaces. There are foreign body giant cells in the stroma with some areas of necrosis. These fibrous cystic changes are characteristic of paraffinoma."

The patient returned four weeks later with an anal fistula which was operated upon, and meanwhile a red and definitely tender mass about one inch in diameter appeared in the



right axilla. Fluctuation soon developed; the mass was opened and drained and about 5 c.c. of seropurulent fluid was obtained. Healing occurred by secondary granulation after two weeks during which there was a fair amount of daily discharge.

Subsequent neurologic examination was done by Dr. Byron Stookey who diagnosed an atrophy of the facial muscles as a probable result of a discrete lesion of the nerve nucleus.

#### COMMENT

After paraffin is injected under the skin it remains soft and pliable, usually for a number of years, but then it gradually hardens and visible changes occur in the tissues.

Paraffin ( $C_{27}H_{56}$ ) in its chemically pure form is not directly toxic to the person using it, but acts as a foreign body. It irritates the surrounding tissues so that connective tissue strands grow into it and the enmeshed paraffin becomes a hard tumor. This chronic inflammatory condition in some cases may develop to the point of ulceration, and after the skin has broken down the paraffin may exude. Although the paraffin is likely to cause such pathologic changes, it cannot be stated that all injected cases exhibit such late complications, although Mook and Wander stated that a single injection of paraffin may lead to the production of tumors. Considering the relatively small number of paraffinomas one cannot assume that such tumors develop in every case although we have no definite proof such as would be furnished by a follow-up on all injected cases. It might be supposed on the other hand that paraffinomas develop earlier in individuals who are more susceptible to the irritation caused by the paraffin injections and in the majority of such cases the tumors appear five to twenty years later. These disfiguring tumors often have to be excised together with all the paraffin-bearing tissues to prevent recurrences. This may necessitate complicated plastic reconstruction.

The actual reason for the paraffin injection in our patient is not clear. According to him it was done in an effort to treat his

nervous condition. A more likely explanation might be that the alleged x-ray treatments were employed to produce epilation on the right side of the chest and face, which in addition to an artificially tumified breast, would produce a feminine appearance of one-half of the body and permit him to earn a living as a side-show freak.

Paraffin injections should be condemned as harmful to the patient, causing late complications which often require plastic surgical operations and transplantations of autogenous tissues to correct the malformations and deformities so caused. In the plastic correction of disfigurements and defects autogenous material, for example, fatty tissue, should be used.

#### SUMMARY

One case is described of paraffinoma of the male breast which developed two years after the injection of paraffin for an undetermined purpose and in which there is a four year follow-up. No definite conclusion can be reached as to whether paraffin injections cause malignancies, although the tumor called paraffinoma (foreign body granuloma) might follow many months or years after the injection of paraffin of lower ( $40^{\circ}\text{C.}$ ) and higher ( $58^{\circ}\text{C.}$ ) melting point.

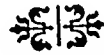
The treatment of choice is a thorough extirpation of the paraffin-bearing tissues, followed, if necessary, by plastic repair.

In plastic surgery the use of autogenous material is recommended.

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ONCE an infection has gained a foothold, it is obvious that a few million dead bacteria [in a vaccine] cannot stimulate the production of immune bodies as well or as rapidly as the many live organisms already invading the body.

# STOMA STRAIN FOLLOWING GASTRIC SURGERY

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A REVIEW of the literature reveals no mention of stoma strain following gastric surgery. Ptosis of the abdominal viscera has been discussed at length, but not in association with the various operations performed for ulcer or carcinoma.

In the three cases which are presented, the main complaints were pain, weakness, vomiting, fatigue, and the inability to carry on work, especially when the patient was standing for any length of time. These patients were tall, thin and long-waisted, with relaxed abdominal walls. All three were operated on for peptic ulcer, Case II having been operated upon twice, but the weakness, fatigue and ulcer syndrome persisted. The recurrence of the ulcer syndrome was aided by the indiscretions of the patients, all of whom used tobacco and alcohol in more than moderate quantities. The pain, vomiting and heartburn of the ulcer syndrome cleared up with rest, alkalis, diet and sedation, but the weakness and fatigue persisted. The fact that the operations had been performed by excellent surgeons led me to consider other factors which would give relief to these patients.

A consideration of the supports of the stomach reveals that the fixed supports of this organ are at the esophagus and the pylorus. The other supports are peritoneal attachments forming so-called ligaments along the lesser curvature (the gastrohepatic) and the greater curvature (the gastrocolic and the gastrosplenic). However, between the esophagus and the pylorus the stomach is simply a flexible, movable bag. In gastric surgery, the stomach is sutured most often to the jejunum, another flexible, movable organ.

Try as the surgeon may, he cannot support the stoma resulting from the operation as the stoma at the pylorus and esophagus are supported. Hence, there is a downward pull by the small intestines and the transverse colon which causes added strain on the stoma. To this factor, add the long-waisted, thin, relaxed abdominal wall which predisposes to ptosis of the abdominal viscera, and the strain on the surgical stoma is undoubtedly increased.

In the following cases, relief has been afforded the patients by the use of a hypogastric supporter, a pad with the convex surface pressing against the lower abdomen, giving support to the abdominal viscera and thereby lessening the strain on the stoma. The relief from strain may also improve the circulation about the stoma, and this would be a factor in preventing the occurrence of marginal ulcer.

CASE I. W. McK., age 67, an electrician, was first seen on March 31, 1936. He had been operated upon at St. Luke's Hospital in New York City about fifteen years previously for stomach ulcers. X-ray revealed a partial gastrectomy.

The patient complained of weakness and fatigue after working a few hours on his feet. He had nausea and vomiting on taking solid food only, and suffered from epigastric pain, relieved by milk and alkalis. Heartburn and loss of weight were further symptoms. This man was a heavy user of alcohol and tobacco. Beyond the stomach complaint he had always been well.

He was a tall, long-waisted individual with a thin, relaxed abdominal wall. His appearance was pale and drawn, he was bent over, and spoke as though extremely tired. The heart tones were dull and there was sinus rhythm. The blood pressure was 150/80, pulse 80,

hemoglobin 70 per cent (Tallquist). Clinically he appeared arteriosclerotic.

Electrocardiograph findings were myocardial damage, without coronary damage.

the small intestine with considerable pull on the stoma, partially occluding it. When the intestinal loops were filled, the pain and nausea began. Medication gave no relief.

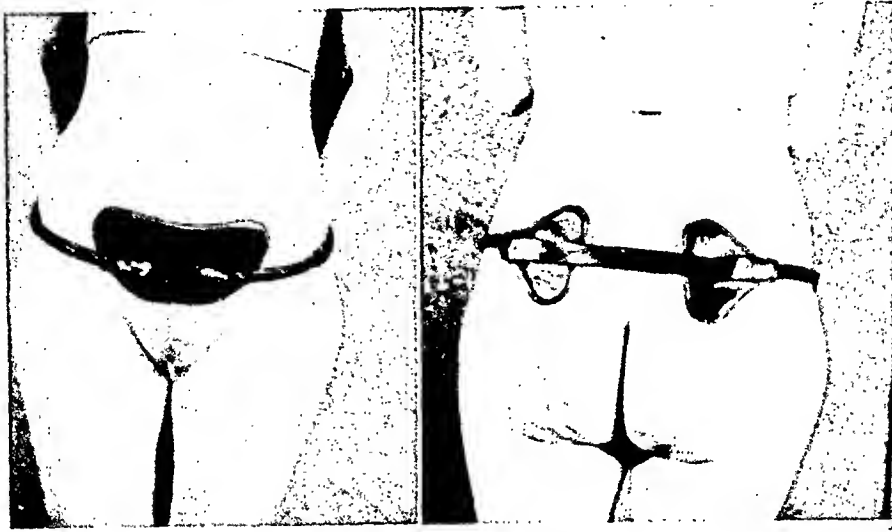


FIG. 1. Abdominal support.

At this time, the diagnosis was one of myocardial damage, with peptic ulcer (marginal), and malnutrition. X-ray revealed an ulcer at the stoma, with no obstruction present. Treatment consisted of twenty-four injections of larostidin, modified sippy diet, and alkali therapy. Within three weeks the pain, nausea and heartburn had subsided. However, the weakness and the fatigue persisted and no gain in weight occurred. The marked ptosis of the small and large bowel was considered to be causing the latter symptoms. Hypogastric support was given, with the result that within two months there was a gradual subsidence of the fatigue and weakness, together with a gain in weight of 20 pounds. In January 1937 there was a slight recurrence of the ulcer syndrome following excessive beer drinking but there was no recurrence of the weakness and fatigue.

CASE II. D. O'C., age 38(?), a policeman, was examined October 22, 1933. He had had a simple gastroenterostomy done at the Lenox Hill Hospital (New York) and a gastric resection at the Mayo Clinic.

He complained chiefly of weakness and fatigue after a few hours in the erect position, epigastric pain, and vomiting (solids or liquids), except when in the prone position. He was a habitual smoker and drank much beer.

This patient was also of the tall, long-waisted type, with thin, relaxed abdominal wall. There was no pathology evident on thorough examination. Fluoroscopy revealed marked ptosis of

Hypogastric support was given, which gave him relief from the pain and vomiting. In two months he gained 20 pounds, and the weakness and fatigue gradually disappeared. Occasionally he suffers acute epigastric distress because of his refusal to give up beer.

CASE III. L. C., age 36, had had a simple gastroenterostomy done at Jefferson Hospital in 1925. This patient complained chiefly of occasional epigastric pain, weakness and fatigue after a few hours of standing on his feet, and occasional heartburn. Heavy use of tobacco and moderate use of alcohol were noted.

The patient was tall, with thin, relaxed abdominal wall, long-waisted in type. X-ray was negative for ulcer. The weakness, fatigue and the inability to gain weight were the principal complaints.

Treatment consisted of application of a hypogastric supporter. In six weeks there was a marked diminution in the weakness and the fatigue, together with a gain of 8 pounds.

The results obtained in the above cases justify a consideration of this appliance in the postoperative care of gastric surgery cases for the body type mentioned. The appliance is simply a metal pad with a convex surface covered with chamois and held in place with two flexible steel bands covered with leather and easily adjusted in the sacroiliac region. The belt is applied

in the prone position with the pelvis slightly elevated.

#### SUMMARY

1. Stoma strain is evidenced by weakness, fatigue and the inability to gain weight.

2. The stomas in these cases were functioning, except in Case II where the pull on the full jejunum partially occluded the stoma.

3. Most chronic ulcer patients are long-waisted and present a thin abdominal musculature.

4. Hypogastric support of the ptosed abdominal viscera relieved the symptoms of stoma strain.

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THE canal of Nuck in the female corresponds to the processus vaginalis in the male and may be the source of herniation of the oblique (indirect) type of hernia.

# CASE OF POSTTRAUMATIC STREPTOCOCCIC MENINGITIS SUCCESSFULLY TREATED WITH SULFANILAMIDE\*

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THE value of sulfanilamide and related substances in the treatment of hemolytic streptococcal infections has been so well established that its application was considered as indicated in a case of a posttraumatic streptococcic meningitis.

## REPORT OF CASE

For the sake of brevity only essential findings are recorded.

M. W., a man 52 years of age, was injured in an automobile accident and was admitted to the St. Elizabeth Hospital January 23, 1937 in a comatous condition.

Examination revealed a black discoloration of both eyelids on the right side, extensive suffusions and crepitation in the right frontal region, multiple bruises and lacerations of the face, epistaxis and broken upper central incisor teeth. The pupils reacted normally to light and accommodation; they were round and equal; no good view of the eyegrounds could be obtained. The patient vomited repeatedly. His blood pressure was 126/80; his pulse 60, and of poor quality; respiration 16, shallow; tendon reflexes normal. The roentgenogram of the skull showed a very extensive, depressed, comminuted fracture of the right frontal bone, extending through the anterior wall of the frontal sinus, the roof of the right orbit and into the base of the anterior fossa. In addition, according to the x-ray report, there was some apparent injury to the other facial bones, including the nasal bone, and an involvement of other nasal sinuses.

A diagnosis of basal skull fracture was made. The head of the bed was elevated, an ice bag applied to the frontal region and external heat to the extremities. Mild silver protein was instilled into the nose and tetanus antitoxin was administered. The fluid intake was limited. Intravenous injections of 300 c.c. of 50 per cent

sucrose and hypodermic injections of caffeine sodium benzoate were given.

Two days after the accident the patient developed a typical delirium tremens. Micturition and defecation were involuntary. The agitation was successfully combated with paraldehyde enemas; no whiskey was given.

On the following day projectile vomiting developed; the patellar, triceps and biceps reflexes were absent, the Brudzinski and Kernig positive, the neck rigid. The reaction of the pupils could not be tested on account of the restlessness of the patient.

On January 30 a spinal puncture was performed, and the fluid was found to be cloudy, but under normal pressure. There was a cell count of 350 per c.mm., and *Streptococcus hemolyticus* was cultured. The patient was given subcutaneous injections of prontosil soluble; the total amount was 120 c.c. the first day and 90 c.c. the following days, divided into six doses daily. The following few days a marked subjective and objective improvement was noticed; the pathologic reflexes were absent; normal tendon and pupil reflexes reappeared.

On February 4 another spinal puncture was performed; the fluid was slightly cloudy, and there were 600 cells per c.mm. Culture showed no growth.

The temperature, which reached 103 degrees two days after the accident, fluctuated between 98 and 100.4 after the prontosil treatment was started. The injections were continued for six days. The patient recovered. Two months after the accident he was complaining of frequent headaches, but there were no other subjective symptoms.

## COMMENT

Recovery from streptococcic meningitis is rare. Gray,<sup>1</sup> in presenting a sum-

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mary of the literature on this subject, reported sixty-six cases, including his own; he believes that the condition is at least 97 per cent fatal. Since his report there have been sixteen cases of recovery reported. Caussée, Loiseau and Gisselbreeht,<sup>2</sup> Schwentker and his collaborators,<sup>3</sup> Anderson,<sup>4</sup> Weinberg, Mellon and Shinn,<sup>5</sup> reported cases with recovery after the use of sulfanilamide and prontosil. However, in none of the cases did the meningitis follow an accident; usually it was of otogenic origin. The achievement of the drug in the case here reported is much more remarkable, as the meningitis was complicated by a skull fracture and delirium tremens, both factors contributing to the seriousness of the situation. It might therefore be advisable to test the prophylactic action of sulfanilamide in skull fractures if the presence of streptococci is demonstrated.

A noteworthy observation was the increase of the cell count in the spinal fluid two days after the injections were started; while before the treatment the count was 350 cells, two days later it rose to 600. Sulfanilamide is known to possess bacteriostatic properties; the above mentioned effect points to an increase of phagocytosis by the drug, as all other medication was discontinued as soon as prontosil injections were begun.

#### SUMMARY

1. A patient with a skull fracture complicated by delirium tremens and streptococcic meningitis was treated successfully with prontosil soluble.

2. To the author's knowledge, this is the first case of *post-traumatic streptococcic meningitis* successfully treated with sulfanilamide.

3. It is urged that the drug be used promptly in cases of post-traumatic streptococcic meningitis.

4. A suggestion is made to test the prophylactic value of the drug in skull fractures after the presence of streptococci has been demonstrated.

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# INTESTINAL OBSTRUCTION FOLLOWING TECHNICAL ERROR IN PERFORMANCE OF WEBSTER-BALDY OPERATION

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AND

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THE operation known as the Webster-Baldy operation for retroversion of the uterus was first introduced by Webster<sup>1</sup> in 1901 and by Baldy<sup>2</sup> in 1903. Although its use has been recommended only in a limited number of selected cases under conditions first emphasized by Polak<sup>3</sup> in 1913, the procedure has been quite extensively and successfully used for the correction of retroversion of the uterus. In 1915 Webster<sup>4</sup> again reviewed his technique for retroversion, intending to emphasize the various stages in the procedure and with special reference to a step which bears repetition in this report. Webster states that in the procedure of the operation, after the round ligaments have been brought through the broad ligaments and have been properly sutured to the posterior surface of the uterus, it is necessary "to close the openings in the broad ligaments, stitching their edges to the round ligaments so that no opening or raw surface is left and there is no chance for the development of a hernia."

In reviewing 100 cases of the Webster-Baldy operations at the Evanston Hospital, not one operative record mentioned the closure of the perforations in the broad ligaments. It occurred to us that an important step was being omitted. Our investigation of the subject was prompted by a recent case which emphasizes the gravity of this error in technique. The case to be presented occurred as a direct but late result of a Webster-Baldy operation. Similar cases have appeared in the literature only twice since the introduction of

the operation (Richardson,<sup>5</sup> 1920, and Pemberton and Sager<sup>6</sup>, 1929).\*

Mrs. O. O., age 45, entered the Evanston Hospital complaining of severe pain in the left lower quadrant of the abdomen, with nausea and vomiting. The onset of her symptoms occurred about six hours prior to admission. She had a normal bowel movement upon entrance and had had two normal bowel movements the previous day. The pain was continuous, not colicky, not relieved by heat, but improved after the use of pantopon. Menstrual history was normal. Further history was negative except that she had had an appendectomy and Webster-Baldy suspension of the uterus fifteen years ago.

Upon physical examination the heart was found to be normal except for occasional extrasystoles; the lungs were normal; the abdomen was not distended, there was a moderate amount of rigidity in the left lower quadrant, with marked tenderness, but no palpable mass. Rectal examination revealed tenderness, especially in the left adnexa. On admission, laboratory findings showed a negative urine and an 11,600 white blood count, hemoglobin 74 per cent, red blood count 3,790,000; temperature

\* Since this paper was submitted for publication there has been another case reported by Arnold, L. E. (*Am. J. Surg.* 41: 498-500, 1938) and one of us (J. E. K.) has participated in another case with Dr. J. L. Hagan.

The latter case had a Webster-Baldy operation ten years prior to the date of entrance to the Evanston Hospital and had two full term pregnancies since her operation. She entered the hospital with severe acute pain in her lower abdomen of six hours' duration, a mass in the pelvis, and signs of acute intra-abdominal catastrophe. At operation a herniation of 8 inches of small intestine was found through the left broad ligament. The bowel was viable immediately following release of the obstruction. The postoperative course was uneventful.



99.4; pulse 100; respirations 20, and blood pressure 140/100. Five hours later the white blood count was 15,800, and her symptoms were

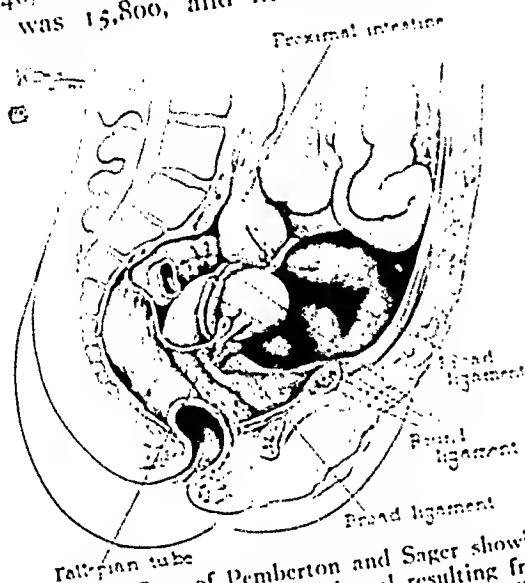


FIG. 1. Case of Pemberton and Sager showing herniation of the small bowel resulting from failure to close opening made in broad ligaments during a Webster-Baldy operation, which is practically identical with the reported case. (From Pemberton and Sager in *S. Clin. North America*, 9: 203, 1929.)

increasing in severity. A preoperative diagnosis of either a twisted ovarian cyst or an intestinal obstruction was made, and abdominal exploration advised.

Through a midline incision there was found in the pelvis a loop of ileum, about 10 inches long, strangulated through the opening in the broad ligament made at the time of an old Webster-Baldy operation. The condition found at operation was practically identical with that pictured by Pemberton and Sager<sup>6</sup> and reproduced herewith. (Fig. 1.) The strangulated portion of the ileum was black and gangrenous, and the peritoneal cavity contained a large amount of dark blood. The obstruction was relieved by removing the left round ligament and Fallopian tube. The strangulated bowel was not viable, and therefore a resection of the necrotic portion was done and an end-to-end anastomosis performed. The patient made an uneventful recovery.

It is obvious that the patient's life was greatly endangered by the technical error in the operation performed fifteen years previously. An explanation of the mech-

anism involved which led to the herniation of the bowel was suggested by Richardson<sup>7</sup> in 1920. He believed that in his case the broad ligaments may have been too thin, or that the round ligaments were grasped too far from the uterus, or that the perforations in the broad ligaments became too large. Considering these possibilities, it is reasonable to believe that should one of the above conditions exist, a recurrence of the retroversion might result, thus placing tension upon the broad ligaments and tearing them laterally, preparing a potential site for herniation of the bowel. We believe that no Webster-Baldy operation should be performed without following closely the steps emphasized in the original articles of Webster and Baldy. The openings in the broad ligaments should be closed with sutures approximating the edges of the broad ligaments and uniting them to the round ligaments. Such a procedure will eliminate any undue tension on the round and broad ligaments and leave no opening to invite herniation.

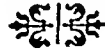
It has been suggested by Polak<sup>8</sup> that postoperatively one should insert a pessary as a prophylaxis in these cases, its purpose being to keep the cervix back, thus permitting the uterus to assume a more normal ante flexed position, thereby diminishing the probabilities of recurrence of retroversion of the uterus, which probably occurs most frequently in the early convalescent period.

#### SUMMARY

1. A case of acute intestinal obstruction fifteen years after a Webster-Baldy operation for retroversion of the uterus is reported.
2. The cause of the obstruction was determined to be a failure of closure of the aperture in the broad ligament through which the round ligament was passed.
3. This danger may be prevented by careful observance of the instructions of the originators of the operation.

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THE power of the blood to rid itself of bacteria is tremendous, at least partially by virtue of the astonishing phagocytic power of the reticulo-endothelial cells which line the blood channels, particularly of the lungs, liver and spleen. One may inject millions of bacteria or tiny foreign particles into the blood stream, and within a few hours they are found to have largely disappeared.

The brief excerpts in this issue are from "A Textbook of General Surgery" by Warren H. Cole and Robert Elman (D. Appleton-Century).

# BICORNUATE UTERUS

## DEAD FETUS IN ONE CORNU, NORMAL PREGNANCY IN OTHER

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ON May 29, 1937 a young white woman was referred to me because of a mass in the abdomen, accompanying pregnancy, which was causing severe pain.

The patient knew that she had had a mass in her abdomen for six months, but since her present pregnancy of about three and one-half months, the mass at the side of her uterus had become more painful and seemed to enlarge with the pregnancy. The pain and discomfort was so severe that she had come for advice.

One normal pregnancy had taken place three and one-half years before and a second two and one-half years before. Two years previous she was examined, was told she had a retroversion, and received pessary treatment for a few months. Four months after her last childbirth her menstrual periods became regular and remained so (six day periods) until September 1936, when the period lasted for three days only, and was accompanied by severe cramps. Not long after, the patient became conscious of the mass in the abdomen. She thought she might be pregnant although her menstrual periods continued to be normal and she did not notice the mass getting any larger.

A physician examined her in January 1937 and told her she had a fibroid uterus which should be removed if it became any larger. In March her menstrual period was again only three days in duration, but was not painful. She did not menstruate in April but did in May. She had no further menstrual periods previous to admission to hospital.

Our examination, May 29 and June 23, 1937, revealed a healthy young woman 21 years of age. Her general examination was essentially negative. Abdominal examination revealed that there was a normal pregnancy of about three and one-half or four months' duration. At the right side of the pregnant uterus was a mass which gave the impression of being a fibroid of large size. As the condition was becoming more severe with the progress of

the normal pregnancy, we advised a surgical removal under spinal anesthesia.

When the abdomen was opened, July 2, by a midline incision, a uterus with a normal pregnancy of about four months was encountered. On the upper right cornu of the uterus was a mass about  $4\frac{1}{2}$  inches in diameter. The right tube with a normal ovary came from the mass, as one would suspect from a bicornuate uterus. But the mass itself was discolored and had the external appearance of a fibroid. Because we did not wish to disturb the normal pregnancy, the entire mass with its accompanying tube and ovary was swiftly though carefully dissected from the pregnant uterus without going deeply into its musculature. The serosa of the uterus was closed over the incision in the uterine wall. The whole procedure including opening and closing the abdomen was limited to thirty minutes.

The patient made an uneventful recovery from the operation, was out of bed in twelve days, and returned to her home in fourteen days.

The mass was examined in the laboratory and the following report made: "Material consists of a large round mass  $8 \times 11$  cm., weighing 220 Gm. It has the gross appearance of a fibroid nodule. On opening this mass there appears a macerated fetus and degenerated placenta two to three months of age. The lining portion of uterus is fairly smooth except at placental site. The wall varies in thickness from  $\frac{1}{4}$  to  $\frac{1}{2}$  cm.

"Microscopic sections of the wall of the uterus show some ordinary appearing muscle fibers and give evidence of physiologic hypertrophy of pregnancy. The lining shows hemorrhagic membrane that contains an occasional degenerated chorionic villi.

"Diagnosis: Macerated fetus in cornu of uterus."

On December 15, 1937 this patient was uneventfully delivered with low forceps of a full term, normal infant.

# NEW INSTRUMENTS

## A NEW TYPE OF FOOT BRACE\* FOR THE TREATMENT OF FOOT IMBALANCES

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THE brace herein described was developed to overcome (1) the disadvantages of the metal supports which are often uncomfortable because of their rigidity, and (2) the shortcomings of the so-called flexible appliances which at best are only palliative, and are entirely devoid of corrective potentialities. This brace may be characterized as a firm support having a slight amount of elasticity. The elasticity is present not only in the insole portion of the brace, a property common to all resilient supports, but is equally present in the inner flange, a property not possessed by other braces.

The basic material of this brace, to which it owes its qualities of firmness plus elasticity, is rawhide. These properties are present in rawhide only in its dry state, for when allowed to soak in water for several hours it becomes sufficiently pliable to permit moulding into any desired shape.

### CONSTRUCTION OF BRACE

Thus a rawhide foot brace can be made by moulding the wet hide over a plaster of Paris model of the foot, the negative for which is obtained as for any arch support. The hide is nailed upon the plaster form and allowed to dry thoroughly. It will then maintain its acquired shape as long as it is kept dry. To insure against the moisture of the foot softening and altering its shape, the rawhide brace is treated with celluloid. The brace is then finished

by covering it with any of the thin leathers such as kid, calf or suede.

One sixteenth inch thickness of rawhide is able to support the body weight without using any metal reinforcement. An eighth inch thickness of cork, placed under the dome of the insole is sufficient to limit any excesses in the flattening of the arch when the body weight is applied to it. (Fig. 1.) A quarter to an eighth inch wedge of cork, glued to the under surface of the inner side of the heel of the insole maintains the heel in supination. A further aid to the supination of the heel is the inner flange which extends to the back of the heel where it forms a right angle with the insole. This is distinctly different from all other braces (Fig. 1) where the inner flange extends only to the middle of the heel, and thus fails to limit adequately the pronation of the back of the foot. The inner flange in this brace can be extended to the very back of the heel only because of the resiliency of the flange which allows for enough play in the flange to insure tolerability while it hugs the back of the foot snugly.

### CORRECTIVE ACTION OF BRACE

Besides giving support to the foot and maintaining the correct foot attitude in a passive manner, this brace has an active corrective force. Its positive action is made possible by the arrangement of the elastic

\* From the Department of Orthopedics, New York Post-Graduate Hospital.

insole and elastic inner flange. (Fig. 2.) actively assume the correct posture. Whenever the faulty attitude of pronation is resumed, the pressure area becomes evident.

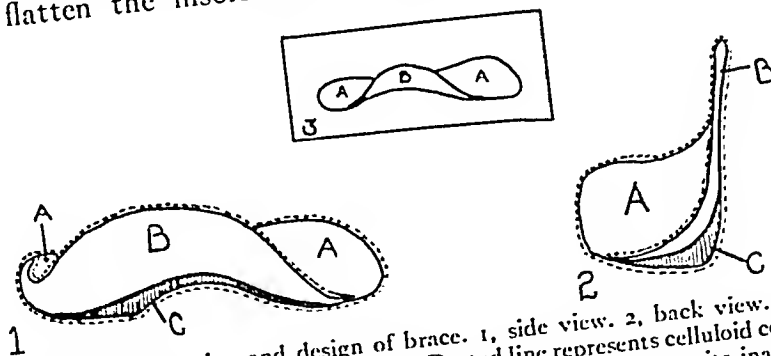


FIG. 1. Construction and design of brace. 1, side view. 2, back view. A, insole. B, inner flange. C, cork wedge. Dotted line represents celluloid coat plus outer leather cover. 3, ordinary arch support. Compare its inadequate inner flange with the inner flange of brace (1) which extends to the back of the foot and partly cups the heel.

would cause the inner flange to move against the foot. Were the pronation of the foot to act alone, it would push the inner flange away from the foot, which in turn would increase the dome of the insole. However, since the body weight and the pronation of the foot act together, and since their forces are exerted at right angles

dent. Thus there exists in the brace a constant but gentle reminder to keep the foot in the proper attitude.

I have used this brace both in the clinic and in my office for the past six years and have found that it has a wide range of applicability to all types of foot imbalances. It can even be worn with comfort

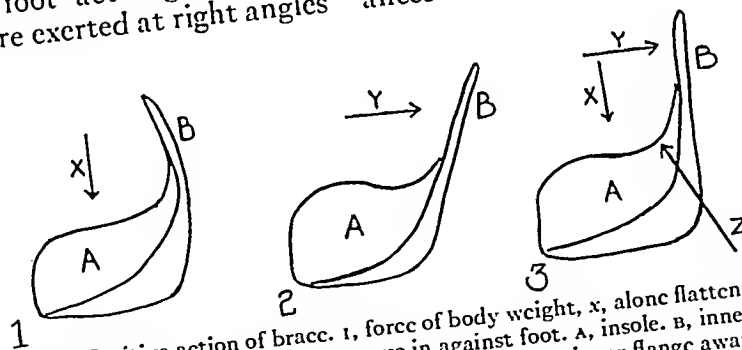


FIG. 2. Positive action of brace. 1, force of body weight,  $x$ , alone flattens insole, causing inner flange to move in against foot. A, insole. B, inner flange. 2, force of pronation of foot,  $y$ , alone pushes inner flange away from foot, raising arch of insole. 3, simultaneous action of body weight and pronation of foot produce resultant force,  $z$ , which is exerted in an upward direction against inner side of foot.

to each other, the result of their simultaneous actions is a force which is located at the junction of the insole and inner flange and is directed upwards against the foot at the astragalocalcaneal level.

This force is not just a theoretic concept but is a real pressure area of which the patient is aware, although it is entirely tolerable. The only way this positive force can be lessened is by having the patient

by a patient with spastic feet, a condition which does not tolerate any rigid support. This brace is extremely light in weight, and is comfortable from the very beginning. It does not have to be "broken in" as is so often the case with rigid braces. Corrections can readily be made when necessary by building up the cork wedge beneath the insole. This can be an office procedure, where felt can be substituted for cork.

# LATHE FOR MAKING BONE DOWELS AND SCREWS

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THIS lathe for making bone pegs and bone dowels provides more accuracy in shaping the dowel and screw, and also saves time.

that steady pressure may be made as the bone fragment is fed into the shaper. A small circular saw may be used in shaping fragments of bone before running them



FIG. 1.

My experience with the old type dowel and screw shaper was disappointing in that it consumed too much time and the pegs were not always straight. With the lathe described, time is cut appreciably and there is a regularity in the shape of the peg.

The lathe may be run from any of the motor saw outfits on the market. It may be completely sterilized by boiling, and is finished in chrome-nickel to prevent corrosive action. The gears are placed in a special housing which may be taken down for care after usage. The gears may be oiled with vaseline after each operation. A flange is built under the platform and this flange engages the edge of instrument table so

through the shaper. This saw has a special attachment and platform for operation.

The bone is fed into the shaper by a small holder which fits into a track on the platform. When fed into the shaper by the holder, the bone is opposite dead center of the dowel. The length of bone that may be fed into dowel-shaper is 3 or 4 inches, so that several pegs may be made at one time. After the dowel is shaped it may be sent through a threader of the size desired. A larger dowel shaper may be used where a peg is to be used for fracture of femoral neck or for intracapsular fractures. The lathe is  $22\frac{1}{4}$  inches in length and  $4\frac{1}{4}$  inches in width.

# IMPROVISED APPARATUS FOR UTEROTUBAL INSUFFLATION\*

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**I**MPROVISED apparatus for performing the Rubin test are numerous, but most of them lack certain elements of control of pressure and volume of gas to be injected, which is usually air. The following is a description of an apparatus improvised by the author at a nominal cost which uses carbon dioxide from an inexpensive source and places under the immediate control of the operator the pressure and the rate at which it is applied, as well as the volume of gas to be injected. Common laboratory supplies and principles are utilized. No claim for originality is made except in the source of the carbon dioxide.

Two bottles (one-half pint milk bottles are excellent because of resistance to breakage) are stoppered with two-hole rubber stoppers. Through one hole of each stopper a long glass tube passes to the bottom of the bottle and the two are connected by a short length of rubber tubing. Into the other hole of the stopper of bottle A is passed a short glass tube reaching to the lower surface of the rubber only, to which is connected a rubber tube 3 feet in length ending at a stop cock with Luer tip. The remaining hole in the stopper of bottle B contains a Y-tube which reaches only to the lower surface of the stopper. To the arms of the Y are attached 6 inch rubber tubes, one terminating with a female Luer connector, the other with a male connector. The two bottles are bound together with several turns of 1 inch adhesive near their bases. A 5 inch metal rod is passed between the glass tubes in the stoppers and is tightened downward by means of wire loops fastened under the lips of the two bottles. This serves a double purpose of

tightening the stoppers and binding the bottles together more securely.

Water containing a dye such as methylene blue is added to bottle A to the upper level of the adhesive band which is marked "0" with a small piece of adhesive. Then 50 c.c. of the water is added at a time and each 50 c.c. level is marked with a small piece of adhesive. A sphygmomanometer with arm cuff detachable from both the manometer and the bulb by Luer connectors is used, the Y-tube of the apparatus being inserted in the place of the bag. A watch for timing the rate of flow is suspended by a cup-hook from the sphygmomanometer frame. A bottle of high grade carbonated water capped with a "fizz cap" used in mixing drinks serves as the source of carbon dioxide for the apparatus. A 2 inch length of No. 14 rubber catheter or pressure tubing of comparable size is attached to the nozzle of the "fizz cap" to receive Luer tip of petcock *a*.

To fill the apparatus with carbon dioxide, petcock *a* is opened and the water in the apparatus is pumped over into bottle A. The petcock is then closed and the control valve of the bulb is opened. The petcock is now connected to the "fizz cap" at *a*<sub>1</sub> and is again opened. With the bottle upright the "fizz cap" is pressed downward allowing the carbon dioxide to escape into the top of bottle A, displacing the water into bottle B. When sufficient gas is collected in A (the water level should be at the mark "0") the "fizz cap" is allowed to close and petcock *a* is closed and disconnected from *a*<sub>1</sub>. When the blood pressure valve is again closed the apparatus is ready for use. Petcock *a*

\* From the Department of Obstetrics and Gynecology, Emory University School of Medicine.

is now ready to be connected to the Rubin cannula and opened.

It will be seen that the rate at which

apparatus is assembled the fittings do not have to be changed and consequently tend to remain air tight. Cost of operation

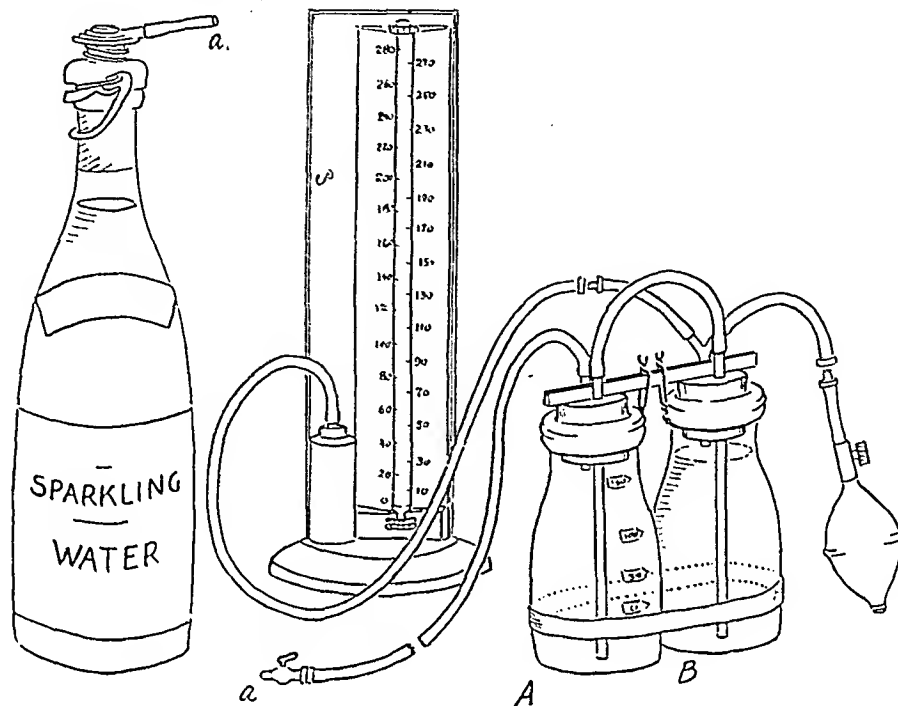


FIG. 1.

pressure is built up in the apparatus is under the direct visual and finger-tip control of the examiner. The maximum pressure and the volume of the gas to be insufflated is likewise under accurate control. The entire process of insufflation can be instantly stopped with a stroke of the thumb against the control valve of the sphygmomanometer bulb. Once the

is negligible; we have averaged eighteen to twenty tests from a 28 ounce bottle of sparkling water costing only a few cents. When the carbon dioxide pressure in the bottle gets low, vigorous shaking will aid in driving it out of the solution. The blood pressure instrument can be immediately restored to its original service as soon as each insufflation is completed.





# A NEW HYPODERMIC NEEDLE SHARPENER

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THE machine here described for sharpening hypodermic needles is driven by a flea power motor (horse power too

A perfectly pointed needle has a manifest advantage over a dull one. A sharp needle is particularly needed for extensive intra-

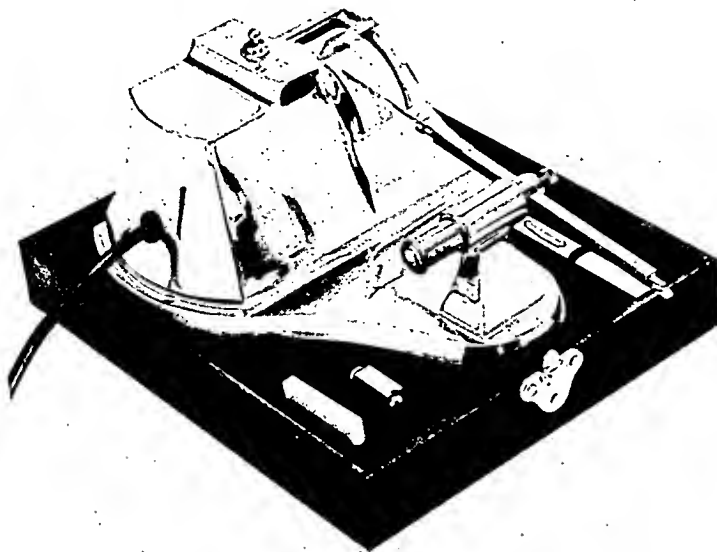


FIG. 1.

small to be rated) which consumes electricity equivalent to a 40 watt electric light bulb. It consists of three special emery wheels, coarse, medium and fine. The head of the hypodermic needle is slipped over a small stud and is held in position by a spring clip. The sliding shaft permits the sharpening of a needle of any length or caliber by adjustment of the sliding arm. An adjustable set gauge is attached to the side of the machine which permits one to sharpen several needles of the same length, and give each one of them the same bevel.

A small accessory attachment permits spinal puncture needles with obturators to be sharpened to the proper angle.

dermal work since the dull needle produces more reaction and more trauma to the tissues. Intravenous work also requires well pointed needles, especially where there is considerable adipose tissue and the veins are small.

The present machine will give a hollow ground point, with any degree of bevel desired, to any hypodermic needle regardless of length or caliber. The slight burr which is caused by the first grinding of the needle is easily removed by a few light brushes across the furnished Arkansas stone.

Several sizes of clean out wires for partially obstructed needles are furnished. These are of spring steel and will not kink.





[From Fernellius' *Universa Medicina*; Geneva, 1679.]

# BOOKSHELF BROWSING

## INCUNABULA MEDICA II—THE YEARS 1001–1100 A.D.

### MONTE CASSINO AND THE SCHOOL OF SALERNO

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IT is to western civilization that one must turn to know and understand Constantinus, the man of learning from another continent. The beginning of the mass folk migrations had already taken place. Wave following wave, Celtic and Teutonic tribes had moved southward and westward, overrunning the outworn Roman empire, and like the Mongols and the Turks in the East, adopting the civilizations and the creeds of those whom they conquered. It was Christianity which gave these new developments their stamp. The glad tidings of a Christ had come to the sick as well as to the hale and hearty. Illness was freed from the odium of sin and the inferiority which had clung to it from primitive times and throughout the days of classical culture. Suffering was a mark of God's own grace and denoted a degree of transfiguration. The sick patient became a privileged person. Through compassion, the healthy could participate in his privileges. Indeed, it became a Christian duty to do all that could be done for the poor and the sick.

In due time the care of the sick was organized upon a grand scale. Great hospitals were built. Benedict, founder of the great order named after him, instructed

the monks of his order to pay special attention to the care of the sick.

Although at the outset, Christianity was fundamentally hostile to classical science, by degrees the new faith became reconciled to it, and reconciled even to pagan medicine. Obviously, a Christian equipped with medical knowledge could be more helpful to the sick than could an ignoramus. Cassiodorus, who held high office under Theodoric, and who subsequently became a monk, declared that a study of classical literature was meritorious for a Christian. The library of the monastery in which he lived to a great age, contained among a vast collection of manuscripts, many of medical content. The Benedictins gradually adopted Cassiodorus' principles, with the result that wherever Benedictin monasteries were established, collections of all available medical and philosophical writings were made, and these monasteries became centers for the study and practice of medicine, places to which the sick were welcomed for Christ's sake, and where likewise the medical lore of the ancient world was studied, insofar as it had been preserved from destruction. Among such

## Cunha—Monte Cassino

centers, St. Gall and Reichenau were worthy of special mention. In the early Middle Ages, doctors were

distribution were brief treatises, extracts, and condensations from the Greek masters, making certain essential facts immediately available for the practice of medicine. The upshot of all this was that the early medieval literature of medicine consisted mainly of collections of recipes, of brief dietetic hints, and of concise monographs upon the pulse, fever, the urine, and blood-letting. These were sometimes couched as letters, sometimes in catechismal form, and sometimes penned in verse, thereby to be remembered the more easily.

We shall look in vain in the medical literature of those days for original ideas. They had been lost in the process of transition, but the medical teachings already extant and those in actual practice daily, were scrupulously preserved. Nor were these blindly transcribed. The monastic medical authors made compilations, indeed, but did so understandingly, and incorporated their own knowledge of popular medicine into the text. The great undertook the care of the sick, and organized it, but even more that in the Dark Ages of misunderstanding, it kept the spark of medical science glowing so that, when the time became ripe, new fires could be kindled. It was not, however, until the second half of the Middle Ages had begun, that there came a man, an African named Constantin, therefore called Constantinus Africanus, who was to give a decisive impetus to medieval medicine.

One cannot but hesitate to describe Constantin as one of the "great doctors." History really knows nothing whatever about his capacity as a physician. His importance to medical science did not lie in the field of actual practice, though nonetheless his medical works and writings had great influence. Who was this Constantin, arriving on the scene from another continent with new ideas, new concepts, strange contacts?

He was born at Carthage, somewhere about the year 1010. Legend clings to his



Fig. 1. Title page from Rhazes "Liber Nonus ad Almansorem" printed in Padua by Peter Maufer in 1480. At Monte Cassino and Salerno the texts of Rhazes enjoyed their greatest popularity.

mainly members of various holy orders. Doubtless there were lay practitioners as well, but they formed an infinitesimal minority. Priests and monks were mainly responsible for keeping the literature of medicine alive, as well as for being medical practitioners. Therefore, there is good reason for speaking of this period as that of "monastic medicine."

In the East the works of the great Greek physicians had been very early translated into Arabic, and their contents assimilated. They had long remained closed books, however, to the Latin speaking West. No doubt some of the writings of Hippocrates, Galen, and other Greek doctors had been Latinized, but they were much too complicated, and had secured therefore but little acceptance. Much more successful in

personality as was customary in those times. His biographer, Petrus Diaconus, informs the world that he visited Babylon, to study there the medical and other sciences of the Chaldeans, the Arabs, the Persians, and the Saracens; that from Babylon he went farther afield into India, whence he returned by way of Ethiopia and Egypt, absorbing on his travels the wisdom and lore of these lands. It is written that his journeyings lasted for thirty-nine years, and that he was heavily burdened with knowledge when he returned to his native city. His compatriots, however, regarded him as a sinister figure, and they planned to put him to death. Having got wind of such an intended assassination, he took refuge on board a ship sailing to Salerno. He remained there for a time in hiding, disguised as a beggar. Then it so happened that the brother of the King of Babylon passed through Salerno, and recognized Constantin, in spite of the disguise, and he was then treated with great honor at the court of Robert Guiscard. He did not find court life congenial or to his liking. Having heard glowing reports of the intellectual life at Monte Cassino, he determined to journey there. On his arrival he secured a very friendly reception from the Abbot Desiderius, so that he decided to prepare himself to become a monk. In the peace and tranquility of the cloister, he devoted himself to the translation of medical works from Arabic into Latin, until, in the year 1087, at his death the pen literally dropped from his hand. His fellow monks chose to remember him as "magister orientis et occidentis," as a new Hippocrates.

This is about all we know about Constantin of Africa; not much, and yet it is sufficient for the present. The account is, of course, legendary, but, like all legends, it contains a kernel of truth. A truer account will be given in another chapter. There can be no question but that Constantin came into close contact with the world of Islam, that he studied Oriental science, and transmitted it to the West. There exists also ample evidence that he was as well

informed in the western science of his day, and it is known that he wrote in excellent Latin, differing greatly from the barbaric

10

*De mentha*

*Mentha mentha, ut est defoliosa linte  
Platui lumbicis, stomachi anemogues moros.*

*De salvia*

*Salvia mentha, qui valia excretion horto.  
Lentia non mentha, qui est medicamentum in horto.  
Salvia confortat viscerum, manumque traxerunt  
Lilii, et opus quo felix aucta fegit.  
Salvia, carum unguis, laurodula, pumula unis,  
Rostis: althamiam, vanam, pentalicia onambaz  
Salvia valentia, pentalicia, conalidap.*

*De Ruta*

*Nobilis est ruta, quia lumen reddit acuta,  
Rupit ruta, qui quippe videtis acuta,  
Ruta cometa recens, oculus caliginis purgati,  
Ruta viscerum unguis, pentalicia, adit,  
Ruta pentalicia, dat lumen, et superat acuta,  
Lentia, facit ruta, de pulchritudo loca lute.*

*De capris*

*De capris, medicum non cometa videtur,  
Lentia, non est lumen, ad ipse galonius,  
Rupit, quia non est lumen, putat, ipse valubus,  
Non medicum, non est lumen, putat, ipse valubus,  
Rupit, quia non est lumen, putat, ipse valubus,  
Lentia, non est lumen, putat, ipse valubus,  
Rupit, quia non est lumen, putat, ipse valubus,  
Lentia, non est lumen, putat, ipse valubus,  
Rupit, quia non est lumen, putat, ipse valubus,  
Lentia, non est lumen, putat, ipse valubus,*

*De vitis*

*Est medicum, granum, vicum, calidumque, vitis  
Rupit, quia non est lumen, putat, ipse valubus,*

Fig. 2. A page from a student's notebook at Salerno, written in the thirteenth century.

phrasing of the monastic medical writers of previous centuries.

Constantin's medical significance lies in his role of intermediary. As if with a magic key, he opened the world of the East to the West. Medical literature had become dry and arid. The monastic medical writers had been chewing over the same texts for half a millennium. Although these texts had sufficed for a time to guide medical practice, they were being superseded. Medicine was engaged in the act of breaking away from the Church. Education was no longer exclusively a clerical affair; there existed now educated laymen as well, and they had nothing to hide, so brought much into the light. Centuries were still to elapse before independent productive work was once more to become possible, but intelli-

gent men were thirsting for better instruction. Constantin had made it accessible to them. Medical men were enabled, by his

## De Anima

## Folio 1.



## Folia incipit libri de

Fig. 3. Title page of Aristotle's "De Anima" printed in Cologne in 1490, by one Quentell. In manuscript form prior to the invention of printing, it comprised one of the most popular medical texts at Salerno.

translations, to read the writings of the great Arabic physicians, though not those of Rhazes, or Avicenna, which would have been beyond their comprehension. The medical men were still in the kindergarten stage. The works translated by Constantin were those of much less noted authors, tenth century writers such as Isaac the Jew, Ali Ibn el-Abbas, etc.

By the same Arabic route, the practitioners of his day became acquainted with the writings of the old Greek physicians, with the aphorisms of Hippocrates, his Prognosis, his Dietetics—books which many hundred years before had been translated into Latin, but had not been understood and had therefore been forgotten. Returning anew to the West by way of the East, they were eagerly read. With Hippocrates came Galen, Galen's commentary on the Hippocratic writings,

his great work on therapeutics, and his little Ars Medicus. Galen, who already dominated Oriental medicine, began now to achieve the conquest of the healing art in the western world.

What gave Constantin's translations so speedy an influence was that they became textbooks at the School of Salerno, where they appeared at an apt moment. Salerno was a flourishing seaport lying not far to the south of Naples. It was an archiepiscopal see, had a famous cathedral, and many monasteries. In these times it had become widely known for its medical school. As early as the beginning of the tenth century, physicians of Salerno had acquired a fair measure of reputation beyond the boundaries of their principality, not merely as men of learning, but as competent practitioners of medicine. Divergent influences were at work in the place. Classical learning had never completely died out there, although it was dying. Greek was still understood, forming a supplementary language to the local Italian dialect and the Latin of the learned. There was a brisk trade between the town itself and the Orient. Arabic knowledge found its way into the place mainly by way of the adjoining Island of Sicily. There is a legend relating to the foundation of the School, to the effect that one day four doctors, a Greek, a Roman, a Saracen, and a Jew, decided upon the joint composition of a book of recipes or prescriptions, and thereby founded the school. This story gives a key to the characteristics of Salerno. It was a place where laymen and clerics of varied religions and nationalities, therefore opinions, could collaborate in friendly rivalry.

In this little community of Salernian physicians, the translations of Constantin had become known. The fertilizing effect was amazing, the growth astounding. Those who had been no more than ordinary family practitioners became suddenly men of great learning. Salerno developed into a "civitas hippocratica," just as, at an earlier date, Constantinople had in the

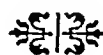
East. A medical faculty, the first medical faculty of the West, came into being. During the twelfth century the School gave birth to an extensive literature; prescription books, textbooks of special pathology and therapeutics, monographs upon fever, the urine, the pulse, diet, treatises on surgery and on gynecology. Anatomy was once more studied, after having fallen for some time into disrepute. Animals, especially swine, were prepared for anatomic dissections and demonstrations, and brief handbooks on the subject were penned. Throughout these writings, in every line, was felt the influence of Constantin. The new knowledge which he had brought to the West was being elaborated upon, the teachings of the Greeks and of the Arabs were being harmonized with the experience of the medical men of Salerno. But the latter felt humble-minded in the face of the achievements of the great masters. How could they have done otherwise? Even today, we of the twentieth century should do likewise.

We should err were we to suppose that the Salernians of the twelfth century did original scientific work, or that it would have been reasonable to expect such work from them. Their main object was to learn. They learned the art of the practice of medicine at the bedside. They learned their facts and prescriptions from the new literature made available to them. Working over and over again on what they had learned, they passed it on to others, sometimes by word of mouth to the pupils, who came in ever increasing numbers to Salerno, sometimes in their books and writings, in the new medical literature they produced. This new literature was enormously superior to the writings of earlier monastic medicine, therefore easily supplanted it. They saw no reason for formulating new theories. The Greco-Arabic science, whose wealth had so recently and surprisingly been disclosed to them, provided sufficient explanation of all

things, and fully gratified their scientific thirst.

The names of many of the Salernian physicians became so well known over the world, and were so indelibly imprinted into medical achievement, that even today they are fairly familiar. Such were Fra Bartholomaeus, better known as Bartholomeus the Englishman, about whom we shall write in a later chapter, Thomas Aquinas, the Angelic doctor, Platarius, and Copho, also Magister Ferrarius. It is difficult to discern the actual human beings behind these great names. Little can be learned concerning their individual lives, and their books and manuscripts seldom convey a personal note. The work of the School of Salerno resembles that done by a guild of artisans. That is why no attempt has been made here to cast any one of the Salernians in the rôle of the great doctors. We merely make brief reference to the School as a whole, an account of single individuals being supplementary entirely to a chapter upon Constantin of Africa.

Moreover, the School of Salerno had but a very brief but blossoming rôle, that of an instructive, let us even say a stimulating impetus in the history of medicine. It flourished most abundantly during and shortly after the days from 1050 A.D. to about 1200 A.D. In 1195, the town of Salerno was sacked by the Emperor Henry VI, and the school suffered therefrom. Thirty years later, in 1225, the University of Naples, which was to become a formidable rival, was founded by the Emperor Frederick II. Even after this, however, Salerno managed to maintain its reputation for a time, to such an extent that, according to ordinances issued by Roger II of Sicily and by Emperor Frederick II, no doctors were to be allowed to practice within their particular realms unless they had received the "approbatur" of the physicians at Salerno.



# BOOK REVIEWS

DIAGNOSTICS BIOLOGIQUES. By Noël Fiessinger, M.D., Henri-René Olivier, M.D., and Maurice Herbain. Fourth Edition. Paris, 1938. Maloine.

Professor Fiessinger's "Laboratory Diagnosis" has run through four editions and gained two French scientific awards—and has earned both. It is a laboratory manual with a difference. It is aimed to provide for the needs of the physician far away from large medical centers, and shows him how, with a minimum of equipment and cost, he can perform the diagnostic work necessary to give complete care to his patients.

In his introduction to the first edition, the author set himself the task of presenting for each procedure: (1) The materials necessary (*Ce qu'il faut*); (2) The procedure (*Ce qu'il faut faire*); (3) What to look for (*Ce qu'il faut voir*); (4) How to interpret (*Ce qu'il faut dire*). To this end each test is taken up under the four headings and the points are presented with Gallic clarity and powers of organization.

This is one of the few manuals of this type which brings into one volume the procedures of bacteriology, mycology, parasitology, vaccines, hematology, and tests relating to gastrointestinal, respiratory, cardiovascular, metabolic, renal and nervous function.

It is probably doubtful whether an average practitioner could find the time or the occasion to perform all these tests. However, a book of this type prepares him to handle intelligently the work he must do and to interpret intelligently the work done by others. It is literally "multum in parvo."

SURGICAL TECHNIQUE AND PRINCIPLES OF OPERATIVE SURGERY. By A. V. Partipilo, M.D., F.A.C.S. Third Edition. Chicago, 1938. Chicago Post-Graduate School of Surgery. Price \$10.00.

Ten contributors discuss different aspects of surgery in this third edition of Dr. Partipilo's book on Surgical Technique, the first appearance of which was in 1930. It is a serviceable book for the intern on a surgical division, for the resident in surgery who wishes a reference book for points of technique, and for the general

surgeon-physician who finds a certain amount of surgery necessary in his practice.

There are thirty-three chapters (567 pages in all) covering every phase of the subject. The 404 illustrations by W. C. Shepard are excellent. Parts of the work are revisions and parts are entirely rewritten. It is therefore timely and up-to-date.

SURGICAL ANATOMY. By C. Latimer Callander, M.D. Second Edition. Philadelphia, 1939. W. B. Saunders. Price \$10.00.

This is an excellent book, now presented in a second and entirely reset edition. The first edition won universal praise from book reviewers and this praise was echoed by those who bought the volume. What more can or need be said?

Anatomy and its surgical application are considered together or in close sequence. The writing is uniformly good. The illustrations are excellent and in every case serve a purpose. The book is 858 pages long and has an ample index.

To both student and surgeon it represents a book which definitely belongs on the library shelf, to be referred to many times in the course of the day's work.

ALCOHOL IN MODERATION AND EXCESS. By J. A. Waddell, M.D. and H. B. Haag, M.D. Richmond, 1938. William Byrd Press. Price \$1.00.

In response to a resolution passed by the Senate and House of Delegates of the Legislature of Virginia in 1936 that called for "accurate information as to the effect of the use of alcohol upon the human system, in respect to both moderate and excessive use thereof," researches were made which are recorded in this book.

The chapters cover, "Introduction to the Study of Alcohol," "The Action of Alcohol on the Body," "The Action of Alcohol on the Central Nervous System," "The Action of Alcohol on the Other Body Systems," "Miscellaneous Topics Pertinent to the Action of Alcohol on the Body," "Acute Alcoholism and



Chronic Alcoholism," and "Statistical Data Pertinent to Alcohol and Its Effects."

This work (184 pages, indexed) compiled by eight distinguished Virginia medical educators is an unbiased and valuable presentation of the subject.

**CHRONIC DISEASES OF THE ABDOMEN.** By C. Jennings Marshall, M.D. New York, 1939. Little Brown.

Donald C. Balfour in the Foreword says, ". . . it is immediately apparent that Dr. Marshall has succeeded admirably in what he set out to do, namely, to make available to the practitioner a small but comprehensive volume in which significance of signs and symptoms as they are related to abdominal diseases can be readily found."

This book consists of 247 indexed pages, of which Part I is concerned with case taking and physical examination, Part II with differential diagnosis.

It is not simple to diagnose some of the chronic diseases of the abdomen, and this well written book, based on long clinical experience, contains valuable aids in this direction. The majority of surgeons and internists could profit by it and—it is not only instructive, but it is good reading.

**A TREATISE ON THE SURGICAL TECHNIQUE OF OTORHINOLARYNGOLOGY.** By Georges Portmann, M.D. Translated by Pierre Violé. Baltimore, 1939. Williams & Wilkins. Price \$12.50.

This is a splendid work for any physician who does ear, nose and throat surgery. It is a translation of Portmann's famous work published in France, and, we remark in passing, the translator has done a creditable piece of work. The book has been revised and adapted to American conceptions, we are told, and new procedures have been added. Not knowing the original, we have no means of judging. However, the technique of surgical procedures in this field are described; the writing is clear, fast moving, stripped of padding, and comprehensible.

The book is 675 pages long, beautifully printed (we are not quite used to double columns in books, but it makes for easy and speedy reading), has 474 illustrations and two colored plates. Bibliography and index are, unfortunately, lacking.

**EMOTIONS AND BODILY CHANGES.** By H. Flanders Dunbar, M.D. New York, 1938. Columbia University Press. Price \$5.00.

This work first appeared in 1935 and presents a survey of the literature on psychosomatic interrelationships from 1910 to 1933. In this, the second edition, there is a supplementary introduction and additional bibliography.

This bibliography brings together in some sort of perspective the research material that has combined to develop those concepts in medicine which are the necessary foundation for further research in the domain of psychosomatic problems. Part 1 deals with orientation and methodology; Part 2 summarizes the literature relating to emotions and organs or organ systems; Part 3 contains therapeutic considerations and concluding remarks.

This work should prove of inestimable value to those whose field is the psychological aspect of disease. The author reveals great insight and there is evidence throughout the work of extensive research into the relevant literature. The influence of this book is certain to be wide and telling in the field of mental medicine.

**SURGICAL ANATOMY OF THE HEAD AND NECK.** By John Finch Barnhill, M.D. Baltimore, 1937. William Wood & Company.

This large book (921 pages) will be of interest to the student of anatomy and of great value to the otolaryngologist, the oral surgeon, the dentist and the ophthalmologist. Internists and those vaguely labeled as "diagnosticians" may well refer to it with profit.

The volume itself covers the subject in detail in an interesting and inspirational manner. Although a textbook, it lacks certain elements common to most textbooks. It is not dull and flat, but is stimulating. It is good reading. The style is different; we would have more books written in the author's style and manner. The type is large. The illustrations (431) are good, the colored ones very good. There is an ample index.

This is a *surgical* anatomy, an anatomy that has a practical value to the oral or head



## Book Reviews

surgeon, the man doing otolaryngology, and to the surgeon-dentist.

**THORACIC SURGERY.** A revised and abridged edition of Sauerbruch's *Die Chirurgie Der Brustorgane*. By Ferdinand Sauerbruch, M.D. and Laurence O'Shaughnessy, M.D. Baltimore, 1937. William Wood & Company. Price \$13.50.

The author of this important book needs no introduction to American surgeons who are well aware of the brilliant pioneer work of Professor Sauerbruch and of his influence on the development of thoracic surgery. In 1904, due to the introduction of differential pressure anesthesia, Sauerbruch and those associated with him occupied themselves with the problems of chest disease. The results of these experiences were reviewed in the first comprehensive work on thoracic surgery (*Die Chirurgie der Brustorgane*), which came out in no less than five editions (1918 to 1930). The present volume is a revised and abridged edition of the larger parent work.

The book is 394 pages long, the illustrations (some in color) are excellent. The translation is scholarly and the abridgment reveals good editorial judgment. There is an extensive bibliography and a subject index.

Any surgeon who is concerned with thoracic surgery should own this work and look upon it as his thoracic surgery Bible.

**GROSS ANATOMY.** A Brief Systematic Presentation of the Macroscopic Structure of the Human Body. By A. Brazier Howell,

M.D. New York, 1939. D. Appleton-Century Company. Price \$6.00.

Throughout a considerable period of years the hours allotted to the course in gross anatomy in American medical schools have been progressively curtailed. Yet it is impossible to teach the student "all about gross anatomy." One cannot cram the subject. Once upon a time, when a thousand hours (not the present three or four hundred) were allotted to this subject the student bought and studied a textbook. Today, such works are not textbooks in the true meaning of the term, but reference works. It is impossible for the student to differentiate the important from the unimportant. He learns the book rather than anatomy. Often he relies on a dissecting manual—a practice as pernicious as the employment of a "trot" to the student translating Latin.

With these faults in mind the author has boiled his subject down to the bare essentials and has stressed the underlying principles, clarifying the points which usually puzzle the majority of students. The book is concerned with gross anatomy only, omits histology entirely, and includes only that amount of neurology needed for a proper understanding of the gross field. The author tells us that "It is an exposition of the procedure followed in the course on that subject as given during the 320 hours of instruction in the Medical School, Johns Hopkins University."

We hope students in other medical schools will have this work included in the books they "must" purchase. This book has a service to perform to those who find anatomy a dry, dull subject, a feat of pure memory.



SPECIAL SYMPOSIUM

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# SURGERY OF THE BILIARY TRACT

BY

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# SURGERY OF THE BILIARY TRACT\*

## A STUDY OF THE FACTORS IN SURGICAL MORBIDITY AND MORTALITY

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SINCE the first successful "operation for gallstones," reported by Dr. Bobbs in the June 15, 1867 issue of the *Indiana State Journal of Medical Science* and the first successful cholecystectomy by Langerbuch<sup>1</sup> in 1882, the progress made in the treatment of the surgical diseases of the biliary tract has been phenomenal.

This study involved the critical examination of 5,200 consecutive cases discharged from the Post-Graduate Hospital with a diagnosis of cholecystitis in any form and of any other pathology of the gall-bladder or the bile ducts. Of this group 3,986 were treated surgically and these were examined in detail with especial reference to: (1) past history; (2) present history; (3) physical and laboratory findings; (4) type of surgery; (5) clinical and microscopic pathology; (6) bacteriology; (7) course in the hospital with complications; and (8) mortality. In this paper only the most obvious factors influencing the morbidity and the mortality in this series of cases will be discussed. More emphasis has been placed on acute cholecystitis for it is felt that this represents the gravest problem among the more common diseases of the gall-bladder.

Table I is a summation in terms of operations and their respective mortalities of all the patients operated on in the Post-Graduate Hospital from January, 1920 through June, 1937. This classification of operations is entirely on the operative procedure and the pathologic determinations were made independently by the attending pathologists. This group included every operation performed on the biliary

tract irrespective of preoperative complications and secondary or even primary conditions, the economic status, age and debility of the patient, and regardless of whether the operation was elective or imperative. The distribution between private and clinic patients was nearly 50-50 and while the obvious difference in mortality and morbidity in the two groups was manifest here, it is believed that this factor should have no bearing on the interpretation of the results. It is further our belief that no mere comparison of statistics has any value unless all the factors above mentioned are taken into consideration.

Heuer,<sup>2</sup> in a comprehensive statistical review, collected 36,623 biliary tract operations in which the mortality was 6.6 per cent. Judd and Parker<sup>3</sup> as early as 1924 published a report of a consecutive series of operations on the gall-bladder with a mortality of 1.8 per cent. Less than 4 per cent, however, were acute infections. From that low mortality in a general series, mortality rates are quoted up to 14.2 per cent in one metropolitan hospital. It is obvious that these authors are speaking of dissimilar conditions, with varying severity of disease, stage of surgery, etc.

The gross mortality for biliary tract surgery in our study was 7.7 per cent. In Table I the surgery is divided into three groups, i.e., (1) surgery for the chronic gall-bladder, including nine operations for carcinoma of the gall-bladder; (2) surgery for malignant (permanent) obstructions of the bile ducts, primarily the common duct; and (3) surgery for acute cholecystitis.

\* From the Gall-Bladder Clinic, Departments of Surgery and Medicine, New York Post-Graduate Hospital (Columbia University).

## Biliary Tract Surgery

Cholecystectomy, with or without appendectomy, for the chronic gall-bladder, accounted for 2,438 operations, by far the largest part of the total number. The mortality in this group was 3.61 per cent, which is definitely higher than in many recently published series, including those personally observed by Heuer<sup>4</sup> and particularly those from the Mayo Clinic.<sup>3</sup>

TABLE I  
ANALYSIS OF 3,986 CONSECUTIVE OPERATIONS ON THE  
BILIARY TRACT (1920-1937)

Operation	Total Number	Mortality (No.)	Mortality (Per Cent)
Chronic Cholecystitis			
Cholecystectomy.....	3,240	190	5.8
Alone or with appendectomy.....	2,438	88	3.61
With dochoostomy.....	238	27	11.34
With other operation.....	568	74	13.03
Cholecystectomy with dochoostomy and other operations.....	6	1	16.16
Cholecystostomy.....	66	22	33.3
Alone or with appendectomy.....	43	13	30.24
With dochoostomy.....	16	6	37.50
With other operation.....	7	3	42.80
Total.....	3,306	212	6.40
Obstructive Biliary Disease			
Cholecystogastrostomy.....	52	15	28.8
Choledochostomy only.....	37	13	35.1
Choledochostomy with other operations.....	2	2	100.0
Plastic on ducts.....	5	3	60.0
Total obstructive.....	96	33	34.4
Acute Cholecystitis			
Cholecystectomy.....	517	45	8.82
Alone or with appendectomy.....	428	32	7.47
With dochoostomy.....	89	13	14.60
Cholecystostomy.....	45	13	28.80
With dochoostomy.....	9	3	33.33
Total cholecystostomy (with 3 other operations).....	57	18	29.63
Total acute cholecystitis.....	574	64	10.97
Total for all biliary tract operations.....	3,986	309	7.7

Cholecystectomy with dochoostomy was resorted to in nearly 7 per cent of all gall-bladder excisions. The gross mortality was 11.34 per cent. This represents apparently

a conservative estimate of the risk of invading the common duct. Smith<sup>5</sup> gives a mortality of 33 per cent for common duct stone with drainage, in ninety-eight common duct cases including twenty-two with acute gall-bladder. Glenn<sup>6</sup> reports forty-two cases with a mortality of 9 per cent. The noteworthy feature, aside from the mortality, is the frequency of exploration of the common duct. In 86 per cent of these cases common duct stones were removed.

In all but eight of the 238 cases drainage was employed, the method of drainage varying with the surgeon. The index of 7 per cent common duct intervention represents either the general severity of the cases operated upon in this series or the thoroughness of the surgery. Maingot,<sup>7</sup> in a recent plea for more frequent exploration of the common duct, states that the mortality of cholecystectomy should not be materially increased by so doing if no pathology is found. He places the probable mortality at 2 per cent. In this group the common duct stone cases had a mortality of 12.8 per cent and those without stones 3.8 per cent or not materially greater than for cholecystectomy alone.

The problem of multiple surgery arises in all operative series, but is all too rarely discussed. In 568 operations cholecystectomy was combined with one or more other operative procedures. Only such operations as within themselves carry a possible mortality were included. These "secondary" operations range from resections of the stomach to hemorrhoidectomy. Purely minor secondary surgery, such as the removal of a fibroma or a mole, are not included. The astonishingly disproportionate mortality of 13.03 per cent in this group deserves further consideration.

The infrequent use of cholecystostomy is significant. Only sixty-six operations of this type were performed, with a mortality of 33.3 per cent. They represent but 2 per cent of the operations on the chronic gall-bladder. Macroscopically, from the clinical pathologic standpoint, the gall-bladders on which cholecystostomy was done were as a

rule no more pathologically advanced than those enduring cholecystectomy, but the operative risk was higher. Therefore no comparison is intended. In spite of the attempt of some continental surgeons, notably Juraristi,<sup>8</sup> to popularize cholecystostomy, it has been infrequently resorted to. That the trend continues toward cholecystectomy can be well illustrated by the extensive study by Mentzer,<sup>9</sup> who reported 55.7 per cent cholecystostomies in 1906 and only 4.3 per cent in 1926. Eliason and Ferguson<sup>10</sup> have shown the futility of the operation, except as an emergency measure.

#### OPERATIONS FOR OBSTRUCTIVE BILIARY TRACT DISEASE

Operations primarily for obstruction in the duct system numbered ninety-six, with a gross mortality of 34.4 per cent. Fifty-two anastomoses circumventing the lower common duct were performed. Of these, fifty were cholecystogastrostomies and two were cholecystoduodenostomies. The mortality rate was 28.8 per cent. Thirty-six (71 per cent) were for carcinoma of the pancreas, and the remainder for obstructive pancreatitis. All patients were severely jaundiced. This mortality is singularly like that reported by Bernhard,<sup>11</sup> and by Collier and Winfield.<sup>12</sup> Judd and Parker,<sup>13</sup> and Eliason and Johnson,<sup>14</sup> had slightly higher mortality rates using a number of procedures (38.2 per cent and 40 per cent respectively).

Choledochostomy following a previous cholecystectomy was done in thirty-nine instances, with a mortality rate of nearly 40 per cent. This further emphasizes the contention of Maingot<sup>7</sup> for exploration of the common duct in all cases of cholelithiasis in order to avoid the high mortality of a subsequent operation on the common duct. Only six of the thirty-nine patients had previously been operated on at the Post-Graduate Hospital. Thirty-two of the group had recurrent or overlooked stones. The remainder had stenosis of the common duct.

#### CHRONIC CHOLECYSTITIS

Table II is a summary of the primary factors influencing the morbidity and mortality in the operations for chronic cholecystitis presented in this study. For

TABLE II  
CHRONIC CHOLECYSTITIS  
Factors Influencing the Morbidity and Mortality  
in Surgery for Chronic Cholecystitis

	No. of Cases	Morbidity	Per Cent Mortality
(A) Multiple surgery (Cholecystectomy plus secondary operation).....	575	1.72	13.85
1. With gastroenterostomy.....	128	....	16.4
2. With pyloroplasty.....	111	....	9.9
3. With gastric resection....	61	....	31.1
4. With acute appendix....	31	....	13.0
5. With hysterectomy.....	59	....	11.8
(B) Conservative treatment in acute cholecystitis			
1. Subsided acute.....	474	1.59	11.02
2. With chronic abscess or old perforation into colon	46	2.20	38.0
3. Cholecystostomy in previous acute.....	15	1.58	20.0
(C) Cholecystostomy in chronic*	68	1.50	7.4
(D) Jaundice (especially necessitating common duct surgery).....	254	....	13.0
(E) Delay in surgery for chronic cholecystic symptoms. Series with less than two years' history.....	959	....	1.35
Total series of chronic cholecystitis.....	3,303	1.31	6.4

\* Means cholecystostomy for a previous chronic infection—now followed by a cholecystectomy.

purposes of comparison, a "morbidity factor" has been devised as an index of the immediate postoperative complications. A factor of 1 was given to cases with relatively uneventful recovery, 2 to those with complications usually not influencing the mortality (wound infections, bronchitis, abnormal distention, etc.); and 3 to those with complications severe enough to cause death in themselves (pneumonia, dehiscence, atelectasis, acute cardiac failure, etc.). The general morbidity factor for the entire series of operations on the chronic

## Biliary Tract Surgery

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gall-bladder was 1.31 and the general mortality was 6.4 per cent.

Foremost among the factors influencing this morbidity and mortality was multiple surgery. The morbidity in this group of 575 cases was 1.72, or 135 per cent higher than in the general group and nearly 300 per cent higher than in those cases in which cholecystectomy alone was done. The mortality rate of 13.85 per cent was nearly four times as high as that for cholecystectomy alone. In only eight of these cases was the gall-bladder pathology of such severity that multiple surgery was imperative. These were patients in whom the gall-bladder had perforated into a segment of the gastrointestinal tract with obstruction. Uniformly the gall-bladders removed in instances of multiple surgery had a relatively severe degree of pathology.

Three hundred of the 575 multiple operations were for concomitant disease in the gastroduodenal segment. Only twenty-four were for associated malignancy of the stomach. Thus 9 per cent of the operations done for chronic cholecystitis had surgery for associated gastroduodenal pathology, mainly ulcer. How adversely the addition of cholecystectomy to operations on the stomach affects the mortality can readily be seen in Table II. Cholecystectomy plus pyloroplasty had a mortality of 9.9 per cent. Cholecystectomy plus gastroenterostomy had the disproportionately high mortality of 16.4 per cent. With gastric resection added to a cholecystectomy the mortality rate was 31.1 per cent. Niemeier<sup>15</sup> reported but 2 per cent ulcers in a series of chronic cholecystic cases, while others have reported an incidence varying from 0.9 to 10 per cent. Heyd,<sup>16</sup> in a personal series reported from this hospital, gives the incidence of ulcer as 10.5 per cent in 557 operated cases. The association of chronic cholecystitis with ulcer of the stomach and duodenum is receiving increasing attention in the current literature. That this association in surgery carries a prohibitive mortality in a large series of cases is therefore of great importance.

Thirty-one patients had their gall-bladders removed in the presence of a pathologically acute appendix and in four of these the appendix was perforated. The mortality rate was 13 per cent. In no instance was the gall bladder acute, though in the majority of instances it was of a severe pathology. The mortality rate of 11.8 per cent where hysterectomy and cholecystectomy were done is further evidence that the patient with cholecystitis cannot well tolerate additional surgery.

There were 474 cases with definite pathology indicative of a previous acute cholecystitis. All had subsided completely before operation. In spite of this, the mortality rate was 11.02 per cent. It is interesting that 437 of these patients gave a history of one or more previous acute attacks, quite distinct in the memory of the patient from attacks of colic. Some had been previously hospitalized for an acute attack, treated conservatively, and then discharged as recovered. The correlation between the history and the pathologic report was 87.7 per cent correct. The average time lapse between the last definite acute attack and the operation was 2.8 months. Operation as chronic cholecystitis in this group markedly raises the general mortality.

Forty-six cases of perforation of the gall-bladder occurred in so-called chronic cholecystitis, with a mortality of 38 per cent. Nine of these had perforations into the colon. They are included in the 474 cases reported above. The morbidity factor was 2.20, an extremely high index of severe complications. Cholecystostomy for acute cholecystitis was not an unmixed blessing, as even when the patients recovered from the primary operation, subsequent gall-bladder surgery gave a mortality of 20 per cent.

Sixty-eight patients who had a previous cholecystostomy for chronic cholecystitis were operated on again for a recurrence of symptoms. The mortality in this group was 7.4 per cent and the morbidity 1.50. There is no definite manner of determining the

percentage of recurrent symptoms following cholecystostomy in this hospital but that an uncomfortably large number come to subsequent cholecystectomy has been shown by Judd and Priestly,<sup>17</sup> and by Pratt.<sup>18</sup> Barber and Harrison<sup>19</sup> have shown that 54 per cent of those patients with cholecystostomy who could be traced had a recurrence of symptoms. In our group, 77 per cent had recurrent or overlooked stones.

Jaundice in any form added materially to the mortality in chronic cholecystitis. The mortality rate in 254 cases with jaundice at the time of surgery was 13 per cent. The majority of these patients had common duct stones (86 per cent) while the remainder had, in general, a hepatitis. Five patients had biliary cirrhosis (clinical diagnosis).

The factor so well determined in all types of surgery is that of early operation. This factor seems, however, to be reversed relative to chronic cholecystitis where the usual advice is to delay surgery as long as possible. That the follow-up results in cholecystectomy are universally better in patients with moderately long-standing disease cannot be questioned, and will not be discussed here, but that this must be balanced against a rapidly increasing mortality in the older patient is frequently forgotten. Niemeier,<sup>15</sup> and Judd and Priestly,<sup>17</sup> among others, have discussed this problem. It is, however, not so much a problem of the chronologic age of the patient as one of his physiologic age and of the duration of his cholecytic disease. In reviewing the 3,306 operations for chronic cholecystitis, 959 patients were operated upon who had a total duration of symptoms not exceeding two years, who had no evidence of a previous acute attack, and who did not have multiple surgery done. The mean age of this group was 43 years as against a mean age of 47 years in the general group. Therefore, it can be presumed that the age factor was not significant. What seems significant is that only thirteen deaths occurred in this group. The mortality rate here was but

1.35 per cent, in decided contrast to the general mortality in cholecystectomy—3.61 per cent. It would seem logical to conclude that the major factor in the success in this group was the short duration of their symptoms.

#### ACUTE CHOLECYSTITIS

The 574 cases in this category comprise all the operations on the acute gall-bladder performed during the period of study. No exceptions were made for associated pathology. By using the "pathologic yardstick," we hoped to eliminate most of the error in statistics on the acute gall-bladder. Included, however, are thirty-two cases of undoubted acute cholecystitis in which no pathologic examination was possible because a cholecystostomy was done. They are classified as of pathologically unknown severity but do enter into the results otherwise discussed.

In Table I are found the various operative procedures undertaken for acute cholecystitis with their respective mortalities. It can logically be assumed that those cases having complicated surgery (docho-stomy, etc.) were neglected cases, at least neglected as chronic cholecystitis. Their increased mortality can be anticipated. What relationship this increased mortality has to the attitude of immediate intervention or of delay in surgery on the acute gall bladder is an important problem. An attempt is here made to at least indicate where the answer lies.

Table III is a composite of the important facts determined in the study of 574 consecutive operations for acute cholecystitis. Among the total series of biliary tract operations 14.5 per cent were for acute cholecystitis. This is at marked variance with the reports of Mentzer<sup>21</sup> (4 per cent) and Saunders<sup>20</sup> (4 per cent), but much like that of the more recent statistical studies.

Thirty-six per cent of the total acute cases were clinically and pathologically merely acute cholecystitis. The rest, or 64 per cent, were severe cholecystitis, i.e.,



TABLE III  
ACUTE CHOLECYSTITIS  
Factors Influencing the Mortality and the Morbidity  
in Surgery in Acute Cholecystitis

Factors	No. of cases	Mor- bidity Fac- tor	Per Cent Mor- tality
A) Degree of pathology (Attending pathologist's diag- nosis)			
1. Acute cholecystitis.....	206	1.40	5.85
2. Purulent cholecystitis.....	117	1.46	9.40
3. Gangrenous cholecystitis....	150	1.51	7.33
4. Perforated with abscess.....	16	2.19	0.00
5. Perforated with peritonitis*..	53	2.13	35.85
(B) Complicated cholecystitis (Comparison with acute only)			
1. Acute only.....	206	1.40	5.85
2. Complicated cholecystitis....	368	....	14.10
3. Perforated cholecystitis (known).....	69	.15	26.10
(C) Cholelithiasis			
1. Cholecystitis with lithiasis..	510	....	12.02
2. Non-calculous cholecystitis..	64	....	9.75
(D) Previous evidence of gall- bladder disease (Pathological basis)			
1. Acute attack on chronic....	433	1.56	12.02
2. Acute with no previous in- flammation.....	141	1.53	7.80
(E) Duration of present illness			
1. Operated within 48 hours of onset.....	81 (57 per cent com- plicated)	1.26	15.10
2. Between 48 and 96 hours (2 to 4 days).....	137 (67 per cent com- plicated)	1.47	5.90
3. Between 4 and 7 days.....	104 (67 per cent com- plicated)	1.51	7.70
4. Between 7 and 30 days.....	192 (63 per cent com- plicated)	1.66	16.71
(F) Duration of the preoperative period of hospital observation			
1. 0-6 hours.....	128 (63 per cent com- plicated)	1.51	15.62
2. 6-24 hours.....	297 (58 per cent com- plicated)	1.47	7.41
3. 24-48 hours.....	58 (66 per cent com- plicated)	1.58	10.35
4. 2-24 days.....	91 (68 per cent com- plicated)	1.71	17.59
(G) Preoperative course in hospital (Watchful waiting-all more than 16 hours)			
1. Progressive course.....	180 (57 per cent of de- lay cases)	1.73	19.30
2. Static course.....	100 (31 per cent of de- lay cases)	1.46	7.00
3. Remissive course.....	36 (12 per cent of de- lay cases)	1.65	0.00
(H) Jaundice			
1. Definite past history of jaun- dice.....	101	1.64	15.80
2. Jaundice at time of surgery..	155	1.68	20.60

\* Exclusive of sixteen cases with clinical peritonitis where cholecystostomy was done.

purulent, gangrenous, or perforated. Of the latter group, fifty-three had a free perforation with peritonitis proved pathologically and in sixteen additional cases where cholecystostomy was done, a clinical peritonitis was apparent to the operator. Only sixteen cases had complete localization. That 12.1 per cent proved or 14.5 per cent presumptive peritonitis existed in the operated cases is representative of the experience more recently reported. Branch and Zollinger<sup>22</sup> with 8.6 per cent perforations and Heuer<sup>23</sup> with 20 per cent perforations and gangrene are representative of the recent reports. In spite of these reports, however, Eliason and McLaughlin,<sup>24</sup> and Niemeier<sup>25</sup> believe perforation into the abdominal cavity to be rare. From our observation it would seem that acute cholecystitis is by no means so benign or self-localizing a lesion as was formerly believed.

Heuer,<sup>26</sup> in an exhaustive analysis of 502 cases of perforative cholecystitis, found that the mortality in the various series considered ranged from 33.3 per cent to 52.2 per cent. The mortality rate in this group of sixty-nine proved perforations was 26.1 per cent and for those perforations with peritonitis it was 35.85 per cent. That in this group of perforation with peritonitis there was adequate time to localize may be presumed in view of the fact that the average preoperative duration of illness was eight days.

The presence of stones in the acute gall-bladder did not materially increase either the morbidity or the mortality. The incidence of acute cholecystitis is, however, much higher among patients with stones. In operations for chronic cholecystitis only 60 or 65 per cent had stones, whereas 89 per cent of the acute cases had stones. Wolfson and Rothenberg<sup>40</sup> found that 91.9 per cent of their acute cases had stones and believed that non-calculous cholecystitis perforated more readily than calculous cholecystitis. This is counter to the findings here where but one perforation among a

probable eighty-five perforations had no stones.

The rôle of long-standing chronic cholecystic disease in the mortality of acute cholecystitis is still debatable. Seventy-six per cent of all the acute gall-bladders had clinical and pathologic evidence of a previous chronic inflammation. The mortality in this group was 12.02 per cent whereas the mortality in those without evidence of previous disease was 7.8 per cent. Peculiarly, the severity of the infection, on the average, was equal. This suggests that previous cholecystic disease may play a definite rôle in the operative risk of the patient with acute cholecystitis.

Recent literature has dealt mostly with the problem of when, and when not, to operate in acute cholecystitis. The proponents of early operation, notably Heuer,<sup>26</sup> Zininger,<sup>27</sup> Graham,<sup>28</sup> Pratt,<sup>18</sup> Judd and Grey,<sup>29</sup> Mentzer,<sup>20</sup> Miller,<sup>31</sup> and many others, are increasing in favor. In many instances, however, the defendents of the conservative treatment, notably Pennoyer,<sup>34</sup> Cave,<sup>33</sup> Bass and Bird,<sup>32</sup> Sherwood,<sup>35</sup> and Bruggeman,<sup>36</sup> have had a stronger case statistically. Liedberg,<sup>37</sup> in a recent exhaustive study of the results of ten years of surgery on the gall-bladder at the Lund Surgical Clinic, came to the conclusion that in spite of the apparent operative risk, the acute gall-bladder should be operated on as soon as the patient is reasonably prepared. The "reasonably prepared" may be the crux to the entire problem of the mortality.

Only eighty-one of the 574 cases were operated on within forty-eight hours of the onset of their immediate illness. This small number was not due to a reserve in operating upon the acute gall-bladder, but to the fact that patients did not present themselves for early operation. In this group the mortality was 15.1 per cent or about 40 per cent above the general group. Furthermore, the number of severe cholecystitis cases was less than in the other groups. In spite of this, the group had many fulminating cases including four deaths due to acute

hemorrhagic pancreatitis associated with acute cholecystitis.

Those patients operated on from two to four days after the onset of their illness, fared much better. The mortality rate in this group was but 5.9 per cent and the morbidity somewhat lower. This improvement was in spite of a definite increase in the severe cases. After four days of present illness, the patients operated upon had an increasing morbidity and mortality in direct proportion to the duration of the illness.

The surgeon cannot control the stage at which he sees the patient in acute cholecystitis. Therefore the period of hospitalization, preoperatively, has been analyzed. The disproportionate mortality in early surgery is at least in part explained by this, for those patients immediately operated upon on arrival at the hospital (up to six hours) had a mortality of 15.6 per cent and a morbidity of 1.51 with no higher incidence of severe acute cholecystitis. This must be contrasted with a mortality of 7.41 per cent and a morbidity of 1.47 in those cases operated on with the benefit of a period of preparation (six to twenty-four hours). After this period further observation in the hospital only further increases both the mortality and the morbidity until those patients operated on after twelve days of observation had a morbidity of 2 and a mortality of 22 per cent.

Perhaps greater significance should be given the observation that of 316 cases observed sixteen hours or longer in the hospital, 57 per cent had a progression of their symptoms and of their physical findings. Only 12 per cent definitely subsided. In spite of the clinical course, severe pathology was present in all groups. That the mortality rate was 19.3 per cent in those with an apparent progressive lesion, as against no deaths in those definitely subsiding, only emphasizes the futility of the "waiting policy." This study, however, represents only those operated upon and so is open to much error of interpretation. During the period of 1920 to 1930, how-

ever, only forty-two patients were discharged from the Post-Graduate Hospital with a diagnosis of acute cholecystitis who had not had operations.

These results coincide rather remarkably with those published by Graham and Walters<sup>35</sup> as well as those of Tourgoff.<sup>39</sup> Heuer's<sup>4</sup> statement that the immediate clinical course of acute cholecystic disease gives us an index of whether gangrene or perforation will ensue, but that this has no value in a specific case, is especially true in our series.

Even a cursory examination of Table III will suggest a remarkable similarity between acute cholecystitis and acute appendicitis. The effect of delayed surgery on the severity of the infection, the number of free perforations, the ascending mortality and morbidity as the disease progresses, the uncertainty of its course, and the role of preoperative preparation on the mortality, all have a familiar appearance. The major dissimilar factor is the complication represented by the liver and its influence on the risks of surgery on the acute gall-bladder.

This added risk is partially indicated by the results of surgery where there has been a previous jaundice or where there is jaundice present at the time of operation. In 101 patients a history of past jaundice was secured. The mortality rate in this group was 15.8 per cent and the morbidity 1.64. Both are much higher than the general series. Jaundice at the time of surgery increased the hazard exactly 100 per cent in this group of 155 patients. The mortality was 20.6 per cent and the morbidity 1.68. This remarkable increase can only be explained by the pernicious factor of jaundice.

#### CONCLUSIONS

1. Multiple surgery, in which the gall-bladder is a part, is dangerous and carries a disproportionate mortality and morbidity.
2. Operations on patients with a definite history of previous acute cholecystitis carry a markedly higher risk than operations for chronic cholecystitis. Therefore,

the preoperative preparation should be most careful and the prognosis more guarded.

3. Conservative treatment in acute cholecystitis may seem to be immediately successful but eventually may be disastrous.

4. Cholecystostomy, regardless of reason for choice, apparently carries an eventually higher mortality and morbidity.

5. Jaundice, both in the chronic and the acute infections of the gall-bladder, adds nearly a 100 per cent increase to the morbidity and mortality of the patient.

6. The optimum time for surgery on the chronic gall-bladder is within two years of the onset of definite active symptoms, regardless of the chronological age of the patient.

7. Severe cholecystitis as well as perforated cholecystitis is more frequent than is generally believed.

8. Acute calculous cholecystitis is most common. It does not markedly affect the mortality or morbidity in spite of the fact that it predisposes the patient to perforation and peritonitis.

9. Acute cholecystitis upon a chronic lesion definitely increases the operative risk.

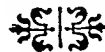
10. The lowest mortality and morbidity in acute cholecystitis is found in those patients operated on within four days of the onset of their present illness and after a period of six to twenty-four hours of hospitalization, long enough to prepare them properly.

11. "Watchful waiting" is pernicious as it does not give a true index of the progress of the disease, and makes for delay in surgery with its increased risk.

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# A COMPARATIVE STUDY OF THE OPERATIVE MORTALITY IN THE VARIOUS STAGES OF GALL-BLADDER PATHOLOGY\*

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THERE were 3,986 consecutive operations on the biliary tract performed at the New York Post-Graduate Hospital from 1920 to July, 1937. The operations were performed by fifty-three attending surgeons. The patients in this group were about equally divided between private and clinic services. The operative mortality and morbidity rate in the series of patients was determined by a study of the clinical history and physical findings, laboratory data, operative findings and procedure, microscopic study and pathologic diagnosis of operative and autopsy specimens, and the postoperative hospital period. Classification of the cases into pathologic groups was made according to the microscopic diagnosis of operative specimens; the macroscopic diagnosis was used only in the few instances in which no operative specimens of tissue were obtained.

A morbidity factor was devised to represent an index of the postoperative complications encountered. A factor of 1 was given each operated case with a relatively normal postoperative course; a factor of 2 where there was a complication of such severity as to prolong the convalescence and yet not ordinarily associated with a mortality; and, a factor of 3 was given to cases with complications potentially fatal. The total factors were divided by the number of cases in the study to give the "morbidity factor."

In making the study in Table 1, the examiner of the case histories was very forcefully impressed by the clinical histories

TABLE 1

	Cases	Per Cent Mortality
Operations for Chronic Cholecystitis		
Cholecystectomy*.....	2,438	3.61
With dochostomy.....	238	11.34
With secondary surgery.....	581	13.85
Cholecystostomy.....	43	30.24
With dochostomy.....	16	37.50
Total for chronic cholecystitis.....	3,316	6.40
Operations for Obstructive Biliary Tract Disease		
Cholecystogastrostomy and duodenostomy.....	52	28.80
Choledochostomy only (after removal of gall-bladder).....	39	38.60
Plastic on the bile ducts.....	5	60.00
Operations for Acute Cholecystitis		
Cholecystectomy*.....	428	7.47
With dochostomy.....	89	14.60
Cholecystostomy.....	45	28.80
With dochostomy.....	9	33.33
Total for acute cholecystitis (with three other operations).....	574	11.97
Total for all biliary tract surgery.....	3,986	7.7

\* With or without appendectomy.

and the pathologic findings of a gradual build-up in the majority of patients with chronic cholecystitis. In the history as well as in the microscopic study of specimens, there was evidence that the gall-bladder patient went through a more or less definite cycle of symptoms and signs of dyskinesia, bile stasis and stone formation, infection with inflammatory changes, loss of gall-bladder function, recurring attacks of

\* From the Combined Medical and Surgical Biliary Tract Clinic of the New York Post-Graduate Medical School and Hospital (Columbia University).

acute inflammation that either subsided or led to operation. The advent of jaundice was notable as the common duct became involved in the progress of the disease. From this period on the common duct was seen to undergo changes that might be compared to those previously noted in the gall-bladder, i.e., dilatation, bile stasis, stone formation, and infection with recurring periods of obstruction during which period the pancreas came into the picture more often than in any other stage of the disease. This picture of an advancing process by stages was evident in the history

and ulceration of the mucosa were noted in those specimens removed from patients with histories of symptoms of more than two years' duration.

In Table II an attempt is made to classify all the patients operated on for chronic biliary tract disease according to the severity of the disease process as interpreted by the pathologist. The clinical stage, the pathologic physiology, and the pathological diagnosis have been correlated. In each category, the respective mortality and morbidity have been given. The clinical and pathologic evidence seems to indicate

TABLE II  
THE CYCLE OF GALL-BLADDER DISEASE AND ASSOCIATED PATHOLOGY  
(As seen in patients operated on as chronic cholecystitis)\*

Clinical Course	Dysfunction	Stone Formation	Cholecystitis with or without Lithiasis	Severe Cholecystitis with Acute Attacks	Jaundice, Common Duct Dysfunction	Continued Acute Attacks, Jaundice	Jaundice, Active Common Duct Involvement
Associated pathologic physiology	Metabolic and dyskinesia	Stasis and lithiasis	Inflammatory changes, loss of concentration power	Ulceration, non-functioning gall-bladder, stones	Dilatation of common duct	Fibrosis, obstruction, perforation	Inflammatory changes, stones, obstruction
Pathologic equivalent	Cholesterosis, "mild" cholecystitis	Mild lithiasis	Thickened gall-bladder, chronic cholecystitis, lithiasis	Severe ulcerative cholecystitis	Dilated common duct (stones)	Hepatitis, perforated gall-bladder, empyema, abscess	Cholangitis, common duct obstruction, stenosis, perforation, pancreatitis
No. of cases in each group	139	820	1213	474	254	70	94
Morbidity factor	1.24	1.22	1.42	1.59	2.04	2.10	unknown
Per cent mortality	1.4	1.34	4.2	11.02	13.0	21.4	26.6

→ Progressive Disease

\* Exclusive of 300 cases with associated gastroduodenal pathology.

in its duration and the incidence of acute exacerbation of symptoms as well as in the corresponding microscopic study of operative specimens in which there was evidence to support the clinical course given. This view is more or less borne out by the microscopic finding of a previous chronic cholecystitis, irregular fibrosis, lymphocytic infiltration and deep scars in those patients operated upon during the acute stages of inflammation. Evidences of previous acute attacks of inflammation, intramural abscess, marked thickening of gall-bladder wall with polymorphonuclear infiltration

that cholecystic disease progresses in a relatively definite manner. Meeker,<sup>6</sup> and Meranze, Salzman, and Meranze<sup>7</sup> have recently correlated the results of surgery on the gall-bladder with the severity of the disease. The latter have especially considered the end-results.

In our series of cases the minimum pathology encountered was designated by the pathologists as "mild cholecystitis" and others as "cholesterosis." On reviewing this group of operated cases we have found many to have symptoms suggesting biliary dysfunction. Cole<sup>8</sup> demonstrated that spas-

tic changes in the biliary tract can cause stasis with resulting progressive pathology. He warns, however, against the danger of too readily placing patients in this group. Mackey,<sup>9</sup> in an extensive study on cholesterosis, states that it is "not a specific lesion but rather a histological feature that may occur at random in gall-bladders showing all grades of pathological changes." In our cases cholesterosis was found to be a relatively benign lesion. The mortality rate in the group having minimal lesions was 1.4 per cent in 139 operated cases and the morbidity factor was 1.24.

A large group of patients with stones and minimal thickening of the gall-bladder wall, as well as a number of patients without stone but with inflammatory elements in the submucosa, follow. Whether infection precedes or follows stone formation is subject to much current controversy. The 820 patients comprising this group had generally mild symptoms, though colic was present in a considerable number. This group represents incontrovertible gall-bladder disease from the pathologic viewpoint. The mortality rate was 1.34 per cent and the morbidity factor was 1.22.

With a continuation of the disease process the gall-bladder passes into a stage of definite infection and inflammation. There is a loss of function readily ascertainable by clinical tests. The clinical symptoms are increased and on drainage and x-ray a pathologic gall-bladder is readily recognized. The largest number of operated cases fall into this group. The mortality rate in surgery on this group of patients increases to 4.2 per cent and the number of severe complications is doubled (morbidity factor of 1.42) in contrast to the preceding group. It is at this stage that the gall-bladder reaches the "critical period" in its disease cycle, i.e., if not removed at or before this time a rapidly ascending morbidity and mortality follow. In addition to progressive chronic inflammation and stone formation, the danger of acute attacks increases. An acute attack is a major catastrophe as it frequently leaves a

non-functioning gall-bladder. With the advent of acute attacks in the cycle the mortality rises sharply to 11.02 per cent and the morbidity factor becomes 1.59. In this group there were 474 cases of chronic cholecystitis with pathologic evidence of a previous acute infection. We have found that each succeeding acute attack increases the mortality by approximately 2 per cent.

At this stage, or perhaps earlier, the common duct begins to take over the function of the gall-bladder, with resulting bile stasis, dilatation and stone formation. In addition, gallstones can now more readily enter the common duct from the gall-bladder. Surgery at this stage of the disease had a mortality of 13 per cent and a morbidity factor of 2.04 in the 254 cases operated upon. Continued gall-bladder and common duct disease leads to a total fibrosis and obstruction of the gall-bladder with associated hepatitis, and the potentiality of a chronic perforation of the gall-bladder. The seventy patients operated on at this stage had a mortality rate of 21.4 per cent and a morbidity factor of 2.10. Continued common duct involvement leads to suppurative cholangitis, common duct obstruction, stenosis, pancreatitis, hepatitis and common duct perforation. In ninety-four cases operated at this stage of biliary tract disease the mortality was 26.6 per cent.

It is difficult to place malignancies of the gall-bladder and common duct into this progressive scheme of pathology. In contrast to the findings reported by Boyse and McFetridge<sup>10</sup> and by Jankelson,<sup>11</sup> only nine instances of primary carcinoma of the gall-bladder were found in 3,986 cases, an incidence of 0.2 per cent. They are therefore not considered here.

There were 574 cases of pathologically proved acute cholecystitis among the 3,986 cases operated upon. Tables III and IV represent brief résumés of these cases grouped according to the severity of the pathology with corresponding mortality and morbidity. Contrary to the rule in



chronic cholecystic disease the severity of the acute pathology bore no relationship to the duration of the present illness. Perhaps the outstanding feature of this series of consecutive acute gall-bladders was the increased morbidity and mortality seen in those patients with definite chronic disease before the onset of their acute attack. (Table III.) In those patients with acute

TABLE III  
THE CYCLE OF ACUTE GALL-BLADDER DISEASE  
(As seen in 574 pathologically acute gall-bladders)

Clinical Course	History of One or More Acute Attacks or a History of Chronic Cholecystitis			
Pathologic equivalent...	Acute on chronic	Purulent	Gangrenous	Perforated
No. of cases in each group	155	92	108	46
Morbidity factor.....	1.45	1.54	1.42	2.14
Per cent mortality.....	6.4	10.7	8.3	53.7

cholecystitis without evidence of previous disease (Table IV) the mortality was 3.9 per

TABLE IV  
THE CYCLE OF ACUTE GALL-BLADDER DISEASE  
(As seen in 574 pathologically acute gall-bladders)

Clinical Course	Single Acute Attack—No Definite History of Previous Cholecystitis			
Pathologic equivalent...	Acute	Purulent	Gangrenous	Perforated
No. of cases in each group	51	25	42	23
Morbidity factor.....	1.26	1.25	1.75	2.11
Per cent mortality.....	3.9	4.0	4.8	26

cent and the morbidity factor 1.26, whereas those with previous chronic disease had a corresponding mortality of 6.4 per cent and a morbidity factor of 1.45. Increasing severity of the disease is accompanied by a mathematical progression in the mortality rate and in the morbidity factor. Forty-six cases with proved perforation on a previously chronic process had a mortality rate of 33.7 per cent. Stones were definitely present in 89 per cent of all acute cases operated. Perforation was present in 12.1 per cent examined pathologically and in 14.6 per cent by clinical observation. This frequency of perforation, in which 70 per cent had a peritonitis, is in marked contrast to the reports of Judd,<sup>12</sup> and Niemeier,<sup>13</sup> who believe free perforation to be rare. It

is, however, concurred in by Heuer,<sup>3</sup> Pratt,<sup>14</sup> and many others.

Graph I shows the mortality and morbidity trends in all cases in which operation was performed for chronic biliary tract disease exclusive of malignancies. Those operated within two years of the onset of definite symptoms had a mortality rate of 2.75 per cent and a morbidity factor of 1.22. This is inclusive of all patients in which a reliable history was obtained. It includes a number of patients who had multiple surgery or had acute attacks. The mortality rate and the morbidity ascends rapidly as the duration of the symptoms increase, until the patients with a definite history of ten years or more had an average mortality of 11 per cent and a morbidity factor of 1.64. Niemeier,<sup>15</sup> and Stevenson,<sup>16</sup> urged earlier operation in recent papers discussing the mortality in chronic biliary tract disease. To be sure Mackey,<sup>17</sup> as well as Judd and Priestly,<sup>18</sup> and many others believe that the longer the duration of the illness and therefore the greater the age of the patient, the better the end result in surgery. Wilson, Lehman, and Goodwin,<sup>19</sup> in a comprehensive study of the follow-up results at the University of Virginia Hospital, found no conclusive evidence of better ultimate results obtained from operation in patients with disease of long standing. We believe that regardless of the validity of the above mentioned reports, the factor of ascending morbidity and mortality in the long duration of symptoms cases is of primary importance.

The same general trend of increasing mortality and morbidity as the duration of the symptoms increases is seen in patients operated upon for biliary tract disease who had concomitant pancreatitis and associated gastroduodenal pathology. Pancreatitis was found predominantly in patients having symptoms of seven to twenty years' duration. This group had an average mortality rate of 18 per cent. Gastroduodenal lesions, necessitating surgery, associated with chronic biliary tract disease are found in a much wider range of "symptom age."

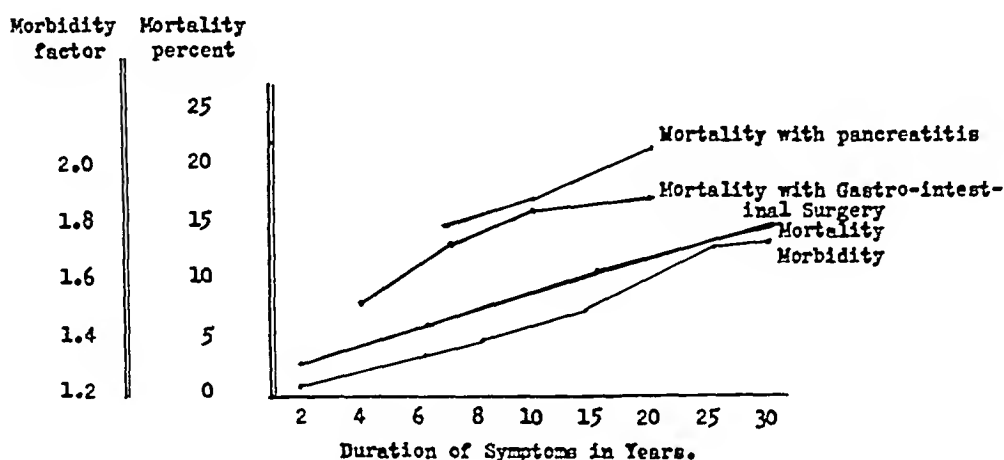


Here the average mortality rate is 16.7 per cent. Again a steady increase in risk is noted as the duration of the symptoms is prolonged.

increments regardless of the severity of the infection at the time of operation.

Table v is a brief statistical study of the results in operating on relatively early

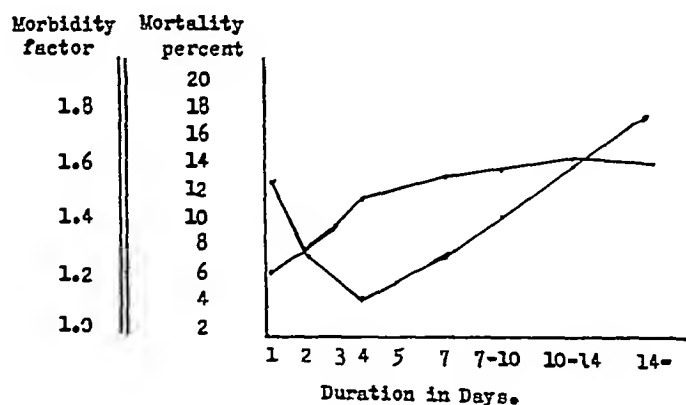
GRAPH I Mortality and Morbidity in Surgery for Chronic Biliary Tract Disease in Relation to the Duration of Symptoms



In Graph II is shown the mortality and morbidity in acute cholecystitis correlated with the duration in days of the present illness. Many factors other than the time element enter into this mortality. They will not be discussed here. It seems apparent

cholecystic disease. All the 1,270 cases were "early" in duration of biliary tract symptoms. There was no absolute correlation between the duration of the biliary tract symptoms and the pathology. There was, however, a general concurrence in that

GRAPH II The Morbidity and Mortality in Surgery on Acute Cholecystitis in Relation to the Duration of the Present Illness.



that the optimum time for surgery is from three to five days after the onset of the attack. On further analysis this proves an unwarranted conclusion. Nevertheless, delay in operating on the acute cases definitely increased both the mortality rate and the morbidity factor by increasing

nearly 80 per cent of the patients in the first two groups in Table II are found in this series. The remaining cases, with short duration of symptoms, were distributed through all stages of biliary tract pathology.

Of the 1,270 cases operated upon in this series, 959 had uncomplicated biliary tract

disease. This "select" group had a mortality of 1.35 per cent and a morbidity factor of 1.22. The addition of an acute attack of cholecystitis, common duct involvement, or gastroduodenal pathology necessitating multiple surgery, increased the mortality rate to 7.1 per cent in 311 cases.

TABLE V

AN ANALYSIS OF THE RESULTS OF OPERATION IN CHRONIC CHOLECYSTITIS WHEN DEFINITE SYMPTOMS HAVE BEEN PRESENT LESS THAN TWO YEARS

	No.	Deaths	Per Cent Mortality
Uncomplicated cases.....	959	13	1.35
Complicated*.....	311	22	7.10
Total operations.....	1,270	35	2.75

Causes of Death		Major Complications	
Pneumonia.....	11	Wound infections (se- vere).....	23
Peritonitis.....	10	Dehiscence.....	15
Liver death.....	4	Pneumonia.....	8
Cardiac failure.....	4	Thrombophlebitis....	5
Operative shock.....	3	Postoperative hemor- rhage.....	4
Postoperative hemor- rhage.....	2	Pleurisy (effusion)....	3
Uremia.....	1	Cardiac failure.....	3
		Surgical erysipelas....	1
		Peritonitis.....	1
		Acute parotitis.....	1

\* Those with previous acute attacks or with secondary operations.

The morbidity factor of 1.22 is low in contrast to that found in patients operated upon after prolonged cholecystitis. In spite of this contrast, the incidence of severe complications was relatively high. Wound infections entailing added hospitalization were present in twenty-three instances, or 2 per cent of the operated cases. Dehiscence occurred in fifteen cases, or 1.3 per cent of all operated cases. Pneumonia and thrombophlebitis were next in incidence. The majority of these complications were found in those patients in whom multiple surgery was found necessary. No specific cause for the high incidence of wound infection and dehiscence could be determined.

The mortality rate of 2.75 per cent in this group is in marked contrast to that found in the general series (6.4 per cent) and that found in those with disease giving symptoms over a period of more than ten years

(11 per cent). Furthermore it is nearly identical with the general mortality seen in the first three stages of biliary tract disease (3 per cent). Pneumonia and peritonitis lead the causes of death with eleven and ten deaths respectively attributable to these causes. The pneumonia deaths were predominantly in the older patients. Peritonitis had a higher incidence in those cases requiring multiple surgery. Only four of the thirty-five deaths were attributed to "liver death" or hepatic shock. These patients died of the typical syndrome described by Heyd<sup>20</sup> in 1923 and since widely recognized. No autopsies were performed on these patients so that even this diagnosis may be in question. Touroff,<sup>21</sup> in a review of the literature on liver deaths, concludes that it is less frequent than first thought, for often a fulminating intra-peritoneal or pulmonary infection escapes detection and mimics liver death. Heyd,<sup>22</sup> in a personally operated series from this hospital, found that 20.5 per cent of the deaths were liver deaths. The low incidence of presumable liver death in the early cholecystitis group is all the more remarkable when contrasted to eighteen of sixty-seven deaths in those patients with symptoms of ten years' or longer duration.

Cardiac failure caused death in four instances. Operative shock was seen in three instances. Two of these patients had, at the time of cholecystectomy, gastric resections for penetrating ulcer. Two patients died of a postoperative hemorrhage. Both were transfused and one was operated on a second time. The hemorrhage in this patient was not due to the release of the cystic artery ligature. The one death due to uremia may well have been due to pancreatic asthenia (Ravdin<sup>13</sup>) as the patient had a common duct drainage.

In an attempt to obviate the diagnostic errors that contribute to the failures of surgery in early cholecystitis, definite indications for surgery on the gall-bladder have been established in the biliary tract clinic of New York Post-Graduate Hospital. These indications are: (1) evidence of stone by means of x-ray visualization and

by carefully checked and repeated biliary drainages; (2) evidence of chronic cholecystitis as shown by marked impairment of function of the gall-bladder with evidence of infection in duodenal drainage; (3) common duct involvement as evidenced by the history, biliary drainage, and blood chemistries; (4) a definite acute attack with operation early in the attack or as soon as preparation is completed; and (5) intermittent jaundice indicative of common duct involvement even without other substantiated findings. Those patients who present early metabolic changes or have evidence of dyskinesia without stones are treated medically.

### CONCLUSIONS

1. Chronic biliary tract disease, in the main, undergoes a definite cycle of progressive pathologic change.

2. The mortality and morbidity rise directly in proportion to the severity of the pathology, as well as to the duration of the disease as shown by the symptoms.

3. Surgery on the gastroduodenal segment, when performed concurrently with surgery on the biliary tract, carries a prohibitive mortality rate and should therefore be avoided.

4. The end results of cholecystectomy for dyskinesia and early cholecystitis are reputedly poor. These poor results can be avoided by a rigid selection of patients, especially by eliminating those with symptoms due to dyskinesia without stones and with no changes in concentrating function of the gall-bladder.

5. The duration of symptoms in acute cholecystitis, unlike chronic cholecystitis, bear no relationship to the pathologic severity. The mortality and morbidity are, however, favorably influenced by early surgery regardless of the pathology involved.

6. The optimum time for surgery in any given disease of the biliary tract is as early as a positive diagnosis of definite destructive pathology can be made.

(a) In chronic disease during the stage of stone formation and minimal inflammation.

(b) In acute disease as soon as the patient can be adequately prepared for surgery.

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# ACUTE CHOLECYSTITIS\*

## WITH DISCUSSION OF FACTORS IN MORBIDITY AND MORTALITY

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THE increased interest in the treatment of acute cholecystitis during the past ten years is shown by the large amount of literature on the subject. There has been a trend toward immediate and early surgery but no unanimity of opinion. A surprising similarity is discernible between the recent literature on acute cholecystitis and that on acute appendicitis as seen between 1900 and 1910. At that time there were immediate, early, and late, operators for acute appendicitis, and only after considerable controversy and the accumulation of a tremendous volume of data, was the early operation universally adopted.

No uniformity of opinion on operation for cholecystitis existed among the thirty-one surgeons of the New York Post-Graduate Hospital who operated upon 574 patients presented in this study. A careful analysis of the immediate results and especially of the causes for the failures, in such a series, is a rational basis for conclusions as to the best method of approach.

The purpose of this paper is to review those factors which increased the mortality and morbidity in treatment of acute cholecystitis, and how these were influenced by the time of operation. The factors here considered are: (1) type of operation; (2) degree of pathology present at operation; (3) presence of stones; (4) jaundice at the time of surgery; (5) past history of cholelithiasis; (6) duration of the present attack; (7) period of preoperative preparation; (8) preoperative course; and (9) the eventual result of non-operative treatment.

The data and conclusions presented in this paper were secured from the records of 574 consecutive cases of pathologically

TABLE I  
OPERATIVE PROCEDURES AND THEIR RESPECTIVE MORTALITY

Operation	No. of Cases	Per Cent Mortality
Cholecystectomy*.....	428	7.47
With choledochostomy.....	89	14.60
Cholecystostomy*.....	45	28.80
With choledochostomy†....	9	33.33
Total.....	574	10.97

\* With or without appendectomy.

† Plus three secondary operations.

proved acute cholecystitis in which operation was performed between January, 1920 and July, 1937. In addition, 474 cases of chronic cholecystitis with pathologic and clinical evidence of a previous acute attack are presented. We believe that the results are those that may reasonably be anticipated in any general hospital of similar prominence and bed capacity.

For the purpose of comparing the immediate postoperative complications a "morbidity factor" has been devised. The morbidity factor is an index of the complications encountered. It is determined by giving an index of 1 to each case with a normal postoperative convalescence, an index of 2 to those with minor complications, and an index of 3 to those with complications potentially fatal. The sum of these indices is divided by the number of cases giving the "morbidity factor."

### (1) THE TYPE OF OPERATION

*Cholecystectomy vs. Cholecystostomy.* A shift in the choice of the operative procedure employed in the treatment of acute cholecystitis can be observed in the recent

\* From the Combined Medical and Surgical Clinic for Biliary Tract Disease New York Post-Graduate Medical School and Hospital (Columbia University).

literature. Smith,<sup>1</sup> Leidberg,<sup>2</sup> Smythe and Mason,<sup>3</sup> Stone and Owings,<sup>4</sup> Heuer,<sup>5</sup> Judd and Phillips,<sup>6</sup> and others have dealt with the advantages of cholecystectomy over cholecystostomy. Eliason and Ferguson,<sup>7</sup> as well as Pratt,<sup>8</sup> have said that the gall-bladder, if once infected and inflamed and especially if once acutely so, never will return to a normally functioning state and must frequently be removed at a subsequent operation.

The number of operations performed with their respective mortality rates are given in Table I.

The mortality in cholecystectomy, 90 per cent of all operations, was 8.82 per cent in contrast to a mortality of 29.63 per cent in the fifty-seven cholecystostomies. This disproportionate mortality rate cannot be entirely ascribed to the poor risk of the patients or their relatively more severe pathology, for in a selected group of cases, comparable as to age, severity of infection, and general condition, the mortality rate after cholecystostomy was twice as great as that after cholecystectomy. In addition to this immediate mortality, we found among the cases of chronic cholecystitis studied fifteen patients who had recovered from a cholecystostomy for acute cholecystitis only to have a subsequent cholecystectomy. The mortality rate in this group was 20 per cent, a factor worthy of consideration when determining the efficacy of the two operations.

*Choledochostomy in Acute Cholecystitis.* It was found necessary to do a choledochostomy in ninety-eight, or 17 per cent, of the 574 cases. Stones were found in the common duct in 82 per cent of those opened for exploration.

In 3,306 operations for chronic cholecystic disease performed during the period of this study, the common duct was explored in only 7.7 per cent of the cases. Failure to consider the common duct in acute cholecystitis frequently leads to operative failure. Judd and Phillips<sup>6</sup> and Beall<sup>9</sup> do not believe that the incidence of common duct disease is high in acute

cholecystitis. Beall further believes that the safest policy in acute obstruction is to temporize. Walton,<sup>10</sup> on the other hand, warns that failure to explore and drain the common duct in acute cholecystitis with obstruction may be fatal. Lichty and Zurhorst,<sup>11</sup> as early as 1915 urged that patients with chronic cholecystic disease come to surgery before the common duct is involved. They recognized that acute cholecystitis is relatively frequent in the presence of common duct disease. The mortality for cholecystectomy and choledochostomy was 14.6 per cent in contrast to a mortality of 33.3 per cent where cholecystostomy was combined with choledochostomy. Leidberg,<sup>2</sup> found a similar incidence and mortality rate in the 556 cases of acute cholecystitis operated at the Lund clinic.

## (2) PATHOLOGY

The microscopic pathologic diagnosis of acute cholecystitis has been used in compiling this series of cases to avoid the varying interpretation and terminology which

TABLE II  
MICROSCOPIC PATHOLOGIC CLASSIFICATION OF ACUTE  
CASES OPERATED UPON WITH THE MORTALITY AND  
MORBIDITY SEEN IN EACH GROUP

Pathologic Diagnosis	No. of Cases	Per Cent of Total Series	Per Cent Mortality	Morbidity Factor
Acute cholecystitis.....	206	36.0	5.85	1.40
Purulent cholecystitis. . .	117	20.4	9.40	1.46
Gangrenous cholecystitis	150	25.9	7.33	1.51
Perforated with abscess..	16	2.8	0.00	2.19
Perforated with peritonitis.....	53	9.2	35.85	2.13
No pathologic report....	32	5.7	34.40	
Total.....	574	100.0	10.97	1.55

thirty-one independent surgeons placed on the macroscopic gall-bladder pathology. Thirty-two patients had no tissue removed upon which a microscopic pathologic diagnosis could be made. This small group is

included because clinically and macroscopically they unquestionably represented acute cholecystitis. The microscopic pathologic report and the macroscopic diagnosis as made by the surgeon coincided in 92.3 per cent of the cases.

A summary of the pathology encountered in this series is presented in Table II. The cases are grouped as to the severity of the infection and their respective mortality and morbidity.

*Acute Cholecystitis.* The pathologic diagnosis of "acute" cholecystitis includes all acute inflammations of the gall-bladder which have not progressed to acute empyema, gangrene, or perforation. Thirty-six per cent of the cases belong to this pathologic group. These cases were, in many instances, early cholecystitis, i.e., early in duration of their acute symptoms. Thirty-four per cent of these "acute" cases were, however, seen after a week's illness. Twenty per cent of the total "acute" cases were non-calculous. Non-calculous cholecystitis predominated in patients with a long duration of the immediate illness.

The mortality rate in "acute" cholecystitis was 5.85 per cent. This was the lowest mortality rate found in our acute series for any pathologic group. In spite of the relatively benign pathology of these cases the mortality was found predominantly in those which had common duct involvement. The morbidity factor in this group was 1.40. This is a rather high index of complications but one lower than in any other group.

*Purulent Cholecystitis.* Acute empyema or purulent cholecystitis was found in 20.4 per cent of all acute gall-bladders operated upon. It was most frequently found associated with an acute obstruction at the cystic duct. Mentzer<sup>12</sup> believes that the initial lesion is an acute infection which, through its associated edema and the efforts of the gall-bladder to empty, causes an acute obstruction. This is our experience as a stone was found impacted at the ampulla or the cystic duct in 89 per cent of all patients with acute purulent chole-

cystitis. The mortality rate in acute empyema was 9.40 per cent and the morbidity factor 1.46.

*Gangrenous Cholecystitis.* Gangrene of the gall-bladder wall was seen in 25.9 per cent of all the cases. This is a higher incidence than is usually reported. Many of these were seen relatively early in the acute attack and they would, most likely, have perforated upon further operative delay. Stones were present in 94 per cent of all gangrenous gall-bladders. The mortality rate of 7.33 per cent found in this group is not high when the severity of the disease is considered. It is lower than that for acute empyema as the duration of the acute illness was generally much shorter. The morbidity factor was 1.51, a slight increase over that seen in empyema.

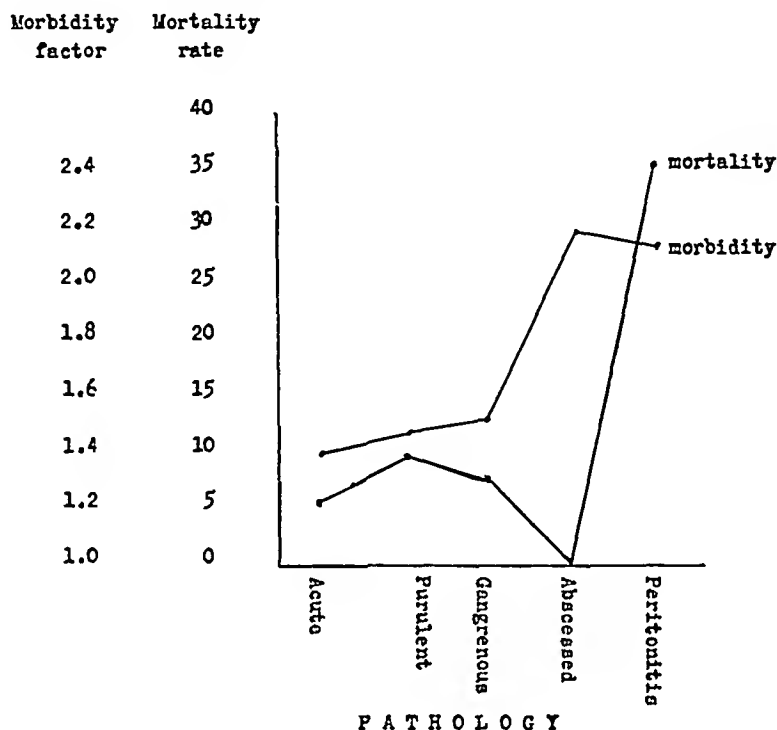
*Perforated Cholecystitis with Abscess.* Sixteen cases of perforation occurred, with localization into a well defined abscess. This represents a surprisingly small number of the total acute cases (2.8 per cent). The serious nature of a perforated gall-bladder is recognized when one considers that only 23 per cent of the proved perforations were localized at the time of operation. Stones were present in the gall-bladder in each instance save one and in this case a common duct stone was found. This low incidence of abscess formation is in marked contrast to that reported by Eliason and McLaughlin,<sup>13</sup> Niemeier,<sup>14</sup> Judd and Parker,<sup>15</sup> Pennoyer,<sup>16</sup> and others. These authors are generally of the opinion that acute perforated cholecystitis tends to localize in the majority of instances. McClure and Altemeier,<sup>17</sup> in an excellent study of acute perforated appendicitis, found in 46.43 per cent of their cases that localization was present at operation. From our study, it is clear that the gall-bladder is less likely to localize than is the acute appendix. The lower incidence of abscess cannot be attributed to early surgery, for the average duration of the acute symptoms in the abscess group was 9.8 days and that of the peritonitis group (exclusive of pancreatitis) was 9.3 days.

No deaths occurred in the sixteen cases after operation for abscess. Cholecystectomy was done in all but one. The number

show that the incidence of perforation is much higher than formerly thought.

The mortality rate for free perforation of

GRAPH I The Mortality and Morbidity in Acute Cholecystitis in relation to the severity of the pathological process.



of severe complications was great, for this group had a morbidity factor of 2.19.

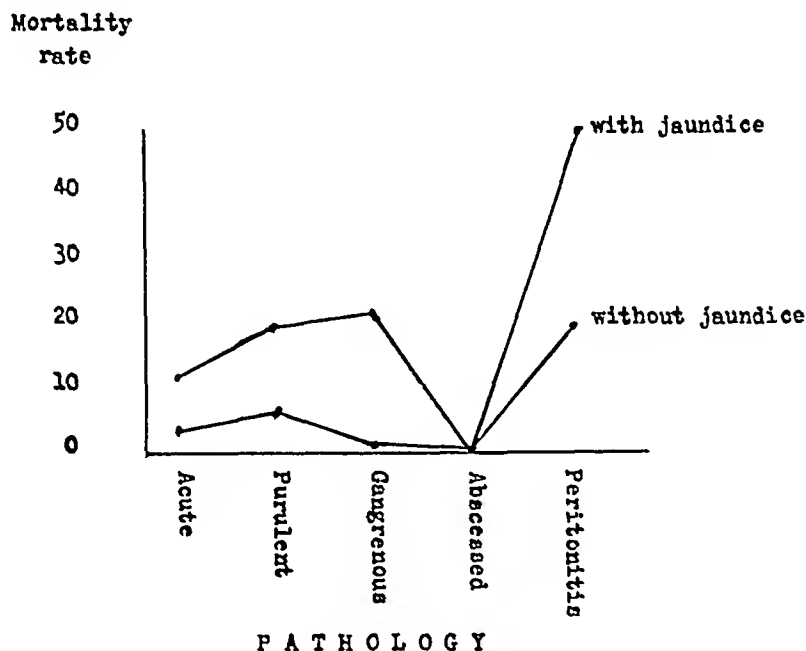
*Perforation with Peritonitis.* Acute perforated cholecystitis with peritonitis was found in 9.2 per cent of all patients operated on for acute cholecystitis. Diffuse or generalised peritonitis was found in 60 per cent of these, having been limited in the rest by adhesion of the omentum and the colon. This incidence is quite comparable to that seen in delayed treatment for acute appendicitis. The incidence of peritonitis in our cases is much higher than that reported by Eliason and McLaughlin<sup>13</sup> (1.8 per cent), Niemeier<sup>14</sup> (0.7 per cent), Smith<sup>15</sup> (2.3 per cent), Mitchell<sup>19</sup> (1.2 per cent), and Leidberg<sup>2</sup> (2.6 per cent). More recent reports by Boyce, Veal, and McFetridge<sup>20</sup> (5.8 per cent), Branch and Zollinger<sup>21</sup> (8.7 per cent), and Heuer<sup>5</sup> (21 per cent for gangrene and perforation)

the gall-bladder was 35.85 per cent and the morbidity factor was 2.13. When all sixty-nine cases of perforation are considered, the mortality rate is 26.1 per cent. Such a severe mortality places the gall-bladder high among the potentially fatal acute conditions of the abdomen. Heuer<sup>22</sup> collected 502 perforations of the gall-bladder from the literature. He found that the mortality rate in this group varied from 33.3 per cent to 52.2 per cent. During the last five years covered by this study there has been a marked decline in the mortality rate due to perforated acute cholecystitis with peritonitis (22 per cent). In this period the number of perforations have decreased slightly though the total operations for acute cholecystitis have increased. We believe that both the decrease in incidence and the decrease in mortality are due to better preparation and earlier operation.

The increase in mortality and morbidity, as the severity of the infection increases, which was experienced in our series, is shown in Graph I.

that the general severity of acute non-calculous cholecystitis is greater than that of calculous cholecystitis. Contrary to our findings, however, they believe that non-

GRAPH II The influence of jaundice on the mortality in Acute Cholecystitis



### (3) CHOLELITHIASIS

Stones were present in the gall-bladder in 89 per cent of the acute cases which came to operation. The general mortality of those with stones was higher than in

TABLE III

A COMPARISON OF THE MORTALITY AND MORBIDITY IN ACUTE CALCULOUS AND NON-CALCULOUS CHOLECYSTITIS

	No. of Cases	Per Cent of Total	Per Cent Mortality	Morbidity Factor
Cholecystitis with stones	510	89.0	11.12	1.57
Cholecystitis without stones.....	64	11.0	9.75	1.40

non-calculous acute cholecystitis (11.12 per cent as compared with 9.75 per cent). As stones were present in all cases with perforation a much higher mortality was anticipated. (Table III.) Actually, acute non-calculous cholecystitis had a higher mortality in the presence of similar pathology. Wolfson and Rothenberg<sup>23</sup> believe

calculous cholecystitis has a higher incidence of perforation.

### (4) JAUNDICE

Jaundice was present in 155 patients operated upon for acute cholecystitis. The pathology encountered in the jaundiced patients was generally more severe than that in the general group. Fifteen per cent of all cases with jaundice had diffuse peritonitis. Common duct involvement was present in sixty-seven of these jaundice patients so that either a choledochostomy or a cholecystostomy was performed. The mortality rate in patients with jaundice was nearly twice that for the general series (20.6 per cent); the morbidity factor was 1.68, a very high incidence of severe complications.

The influence of jaundice on the mortality in acute cholecystitis is graphically represented in Graph II. The lower line is the mortality curve in those cases without jaundice and the upper line is that of cases with jaundice. In each pathologic classification, other than abscess, the presence of



jaundice added greatly to the severity of the prognosis.

### (5) PAST HISTORY

The mortality and morbidity in acute cholecystitis is adversely influenced by a previously existing chronic cholecystitis. Pathologic evidence of a preëxisting chronic cholecystitis was found in 75.5 per cent of the acute cases. They are classified as "acute on chronic" cholecystitis. The clinical history coincided with this pathologic finding in 89 per cent of the cases

where there was a reliable history. The average duration of the chronic cholecystitis symptoms was nine years. It was in this group that common duct involvement was most frequently found associated with an acute cholecystitis.

A comparative study of the mortality as seen in cases operated with an "acute on chronic" pathologic diagnosis and those with an acute "first attack" pathologic diagnosis is shown in Table IV. The mortality rate was definitely higher in each pathologic group in which the patients had evidence of a previous chronic cholecystic disease. This increased mortality is seen in spite of the fact that the severity of the infection was slightly greater in the "first attack" cases. Prolonged liver damage due to neglected chronic cholecystitis is the probable cause for the added mortality. Niemeier<sup>21</sup> and Graham<sup>22</sup> stressed the factor of long standing chronic cholecystic disease as a cause for acute cholecystitis. They found that "acute on chronic" disease is frequently associated with common duct involvement, jaundice, cholangitis, and liver damage. Niemeier<sup>21</sup> found the mortality rate higher in surgery on the "acute on chronic" cases.

The morbidity was generally higher in those cases of acute cholecystitis which indicated pathologic evidence of a previous chronic cholecystitis or a previous acute attack. (Table V.)

TABLE IV  
THE COMPARATIVE MORTALITY IN "ACUTE ON CHRONIC" CHOLECYSTITIS AND IN THOSE OPERATED ON DURING THEIR FIRST ATTACK

Pathology	"Acute on Chronic" No. Cases	Per Cent Mortality	"First Attack" No. Cases	Per Cent Mortality
Acute only.....	155	6.4	51	3.9
Purulent.....	92	10.8	25	4.0
Gangrenous.....	108	8.3	42	4.8
Perforated with abscess.....	11	0.0	5	0.0
Perforated with peritonitis.....	35	37.1	18	33.3
Unknown pathology.....	32	34.4		
Total.....	433	12.02	141	7.80

TABLE V  
THE COMPARATIVE MORBIDITY IN "ACUTE ON CHRONIC" CHOLECYSTITIS AND IN PATIENTS OPERATED ON DURING THEIR FIRST ATTACK

Pathology	"Acute on Chronic" No. Cases	Morbidity	"First Attack" No. Cases	Morbidity
Acute only.....	155	1.45	51	1.26
Purulent.....	92	1.54	25	1.25
Gangrenous.....	108	1.42	42	1.75
Perforated with abscess.....	11	2.10	5	2.40
Perforated with peritonitis.....	35	2.15	18	2.00
Unknown pathology.....	32			
Total.....	433	1.56	141	1.53

TABLE VI  
A COMPARISON OF THE COMPLICATIONS, PERFORATIONS, MORTALITY AND MORBIDITY ENCOUNTERED IN 514 CASES IN WHICH THE DURATION OF THE PRESENT ILLNESS WAS KNOWN

Duration of the Immediate Illness	No. of Cases	Per Cent Complicated	Per Cent Perforated	Per Cent Mortality	Morbidity Factor
Up to 48 hours.....	81	56.8	14.8	11.1	1.26
2-4 days.....	137	67.2	6.0	5.9	1.47
4-7 days.....	104	67.0	12.3	7.7	1.51
7 or more days.....	192	63.6	17.2	16.7	1.66
Totals.....	514	64.0	12.4	10.97	1.51

#### (6) DURATION OF THE IMMEDIATE ILLNESS

When should acute cholecystic disease be operated upon? Around this question has revolved most of the controversy on the treatment of acute cholecystitis. Cave,<sup>26</sup> in a very logical paper, has divided the present surgical opinion into three groups, namely the immediate, early, and delayed operators. He pointed out that none of the operators taking a definite stand on when to operate have done so to the exclusion of all other methods and that therefore the time of operation is dependent upon the judgment of the operator. This is a rational stand and one generally adhered to. In the main, however, surgical thought is divided into a rapidly increasing group of "early" operators and a diminishing group of "conservative" operators.

Foremost among the exponents of early operation are Heuer,<sup>5,22,27</sup> Glenn,<sup>28</sup> Miller,<sup>29</sup> Smith,<sup>30</sup> Graham and Waters,<sup>31</sup> Touroff,<sup>32</sup> Mentzer,<sup>12</sup> Leidberg,<sup>2</sup> and Walton.<sup>10</sup> These are but a few of many "early" operators. The conservative operators include Cave,<sup>26</sup> Pennoyer,<sup>16</sup> Behrend,<sup>33</sup> Smyth and Mason,<sup>3</sup> Bass and Bird,<sup>34</sup> Branch and Zollinger,<sup>21</sup> Bruggeman,<sup>35</sup> and Sherwood.<sup>36</sup> The attitude of an increasing number of surgeons is summed up very well by Heyd,<sup>37</sup> who states, "for the physician to counsel waiting in acute disease is to participate in a surgical gamble that 'under a regime of starvation and local applications, an ascending phase of pathological change will become arrested.' This is distinctly a gamble with the odds against him."

A summary of the effect on the morbidity and mortality in acute cholecystitis of the duration of the present illness is shown in Table VI. The history was reliable in only 514 cases and these alone are presented. In this series there are patients operated upon immediately, early, and late in the course of the disease. The study should, therefore, be of some value in determining the optimum time for surgery. The mortality rate in the eighty-one cases in which operation was carried out within two days of the

onset of their acute symptoms was 11.1 per cent. This is nearly twice that found in the next succeeding group. This high mortality is an apparent argument against early surgery. On further study, eleven of these early cases proved to be fulminating peritonitis, including seven with acute hemorrhagic or suppurative pancreatitis. Eight of these eleven died. If these cases were to be eliminated from this series the mortality rate in patients operated on within forty-eight hours of onset would have been 2.9 per cent. The morbidity factor in these cases was 1.26, an extremely low incidence of severe complications when contrasted to those encountered in delayed surgery.

One hundred and thirty-seven patients were operated upon during the period of two to four days following the onset of acute symptoms with the low mortality of 5.9 per cent. More of these cases had complicated disease (67.2 per cent) than did those operated earlier in their acute attack, but the incidence of fulminating disease was much lower. With the exclusion of the fulminating cases from the earlier group, the mortality in those operated on two to four days after the onset of symptoms was nearly twice that of the first group.

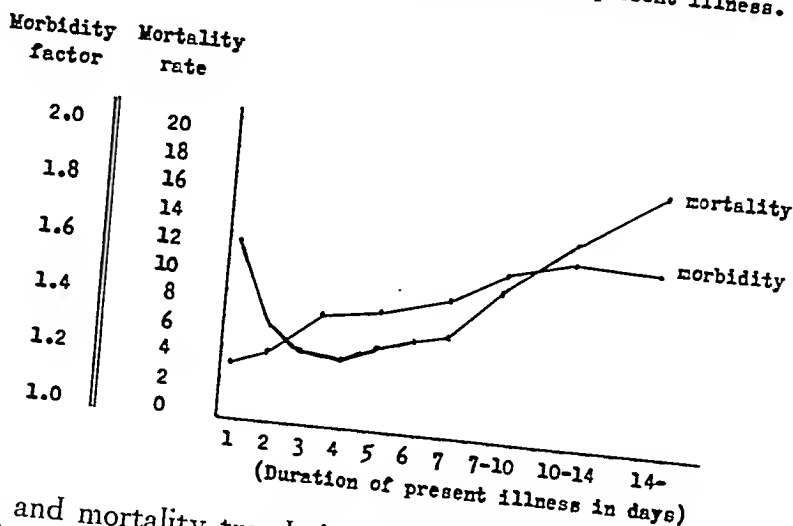
In 104 cases operation was done between four and seven days after the onset of their acute symptoms with a mortality of 7.7 per cent and a morbidity factor of 1.51. In spite of a constant distribution of pathology as contrasted to the earlier operation the morbidity and mortality increased.

The morbidity and mortality increased steadily with longer delay in operating. The largest group to be operated upon were those with symptoms which had gone on for more than seven days. In this group the mortality rose to 16.7 per cent. Actually it was a graduated increase in mortality; those patients operated on two weeks or longer after the onset of their acute attack had a mortality of 18 per cent. The morbidity of this group rose similarly to a factor of 1.66. This represents a very high index of complications in view of the

fact that these patients had, as a group, less severe pathology than the preceding groups.

the preoperative preparation on the mortality and morbidity of acute cholecystitis. The influence of the length of preoperative

GRAPH III The mortality and morbidity in Acute Cholecystitis in relation to the duration of the present illness.



The morbidity and mortality trends in relationship to the delay in operating on acute cholecystitis are represented in Graph III.

#### (7) PREOPERATIVE PREPARATION

The determination of when to operate in the course of disease is all too frequently beyond the control of the surgeon. General

hospitalization on the mortality and morbidity of acute cholecystitis is shown in Table VII.

In the 128 cases in which operation was done immediately upon admission to the hospital (up to six hours) the mortality was 15.6 per cent and morbidity 1.51. This group represents a number of fulminating cases as well as four with acute hemorrhagic pancreatitis. The high mortality cannot be explained on this basis alone for even when these are removed from the group the mortality in immediate surgery is 12 per cent. Judd and Grey,<sup>38</sup> Smith<sup>30</sup> and others have warned against immediate surgery without preparation. It is apparent from the high mortality rate in operating upon patients in an emergency, that this is a pernicious practice. In every pathologic type, other than gangrene, the mortality rate was higher in immediate surgery.

The 297 patients operated on after a period of preparation (six to twenty-four hours) had a mortality of 7.4 per cent and a morbidity factor of 1.47. The general index of pathologic severity was equal to that seen in other groups. These patients were hospitalized long enough for reason-

TABLE VII  
THE MORTALITY AND MORBIDITY IN ACUTE CHOLECYSTITIS  
IN RELATION TO THE LENGTH OF PREOPERATIVE  
HOSPITALIZATION

Duration of Observation Period	No. of Cases	Per Cent Perforated	Per Cent Mortality	Morbidity Factor
0-6 hours.....	128	10.0	15.6	1.51
6-24 hours.....	297	13.1	7.4	1.47
24-48 hours....	56	8.6	10.35	1.58
2-24 days.....	93	12.8	17.60	1.71
Total.....	574	12.1	10.97	1.55

practitioners have not, in the past, hospitalized patients with acute cholecystitis until the progress of the disease had become alarming. For this reason an analysis has been made of the influence of

able preparation and the estimation of their probable surgical risk, and yet not so long as to allow a marked progress in the disease. Eliason and Erb<sup>39</sup> have shown the decrease in mortality and morbidity in surgery on the biliary tract, including acute cholecystitis, which has followed adequate preparation by means of glucose, transfusions, etc. This factor is well demonstrated in this series of cases.

The fifty-six patients operated on during their second hospital day did not fare well. They had a mortality of 10.35 per cent and a morbidity factor of 1.58. A small but definite increase in the severity of the pathology was noted though the incidence of peritonitis decreased. An additional twenty-four hours of preparation had not decreased the operative risk in these cases.

In the ninety-three cases in which delayed operation was practiced we encountered the highest mortality and morbidity in the series (17.6 per cent and 1.71 respectively). In spite of hospital care and observation this group showed progressive pathology. The penalty for delayed operation was a 250 per cent increase in the mortality and a 50 per cent increase in the severe complications.

TABLE VIII  
AN ANALYSIS OF THE CLINICAL COURSE OF DISEASE IN  
316 CASES OBSERVED IN THE HOSPITAL FOR  
EIGHTEEN HOURS OR MORE

Apparent Clinical Course of Disease	No. of Cases	Per Cent of Total	Per Cent Mor- tality	Mor- bidity
Progressive....	180	57	19.3	1.73
Static.....	100	31	7.0	1.46
Remissive.....	36	12	0.0	1.65

#### (8) PREOPERATIVE COURSE OF THE DISEASE

"Watchful waiting" was long considered good therapy in acute cholecystitis. Smyth and Mason,<sup>2</sup> Smith,<sup>1</sup> Cave,<sup>40</sup> and Pennoyer<sup>16</sup> are convinced that observation of the clinical course will determine the necessity for surgical intervention. The

"early operators" are unanimous in condemning this procedure. Touroff,<sup>32</sup> Hener<sup>5</sup> and Mitchell<sup>19</sup> noted that the symptoms of acute cholecystitis may subside and yet the lesion may progress. This has been our experience.

A résumé of the preoperative course of 316 cases observed in the hospital for more than eighteen hours is given in Table VIII. Fifty-seven per cent showed evidence of a progressive lesion with increasing toxemia, temperature, pulse, physical and laboratory findings. In this group the mortality was 19.3 per cent and the morbidity factor 1.73. Waiting to see whether or not the acute infection would subside was a gamble not justified by the results. During this period, to determine the course of the disease, a considerable number perforated and twenty-seven had a peritonitis when operated on. The mortality in this group with delay and then surgery for peritonitis was 48.1 per cent.

In 100 cases it was impossible honestly to determine the progress of the disease. It is probable that most of these cases would have subsided. In spite of lack of evidence of a progressive lesion, six patients had a diffuse peritonitis when operated on.

Only thirty-six patients were operated upon with a course in the hospital that definitely indicated a subsiding or subsided lesion. There were no deaths in this group though fourteen had severe cholecystitis. An additional forty-two patients were discharged from the hospital without surgery but with the diagnosis of an acute cholecystitis. They had all subsided clinically.

#### (9) NON-OPERATIVE TREATMENT

What happens to patients with acute cholecystitis who do not come to surgery? How many are subsequently operated on during an acute attack or as chronic cholecystitis? What are the mortality and the morbidity in these cases? The eventual fate of all patients with acute cholecystitis can only be determined when these questions are answered. In our series it was

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TABLE IX  
ANALYSIS OF 474 PATIENTS OPERATED UPON AS CHRONIC  
CHOLECYSTITIS WHO HAD CLINICAL AND PATHOLOGIC  
EVIDENCE OF A FORMER ACUTE ATTACK

Pathologic diagnosis of former acute attack.....	474
Average total duration of chronic history.....	9 years
Average time since last acute attack (History and clinic record).....	2.8 months
Mortality rate.....	11.20 per cent
Morbidity factor.....	1.59

impossible to answer them, but some information has been gained in analyzing 474 cases of chronic cholecystic disease in which pathologic findings were suggestive of a former acute infection. (Table IX.)

The pathologic evidence taken as suggestive of a former acute infection was by no means conclusive. It consisted of: (1) evidence of scar tissue penetrating the muscular layer of the gall-bladder; (2) chronic ulceration; (3) chronic empyema; and (4) chronic perforation of the gall-bladder. Further evidence was found in that in 87.7 per cent of these cases there was a history suggestive of an acute attack. The mortality rate and the morbidity factor were somewhat higher in these cases than in those operated for acute cholecystitis. They were remarkably higher than these same factors in the 3,306 cases of chronic cholecystitis of which they were a part. The general mortality of all cases of chronic cholecystitis was 6.4 per cent and the morbidity factor 1.31.

## CONCLUSIONS

1. The results of cholecystectomy for acute cholecystitis are superior to those of cholecystostomy regardless of the severity of the disease encountered.
2. Common duct disease is frequently present with acute cholecystitis. When present, it adds greatly to the operative risk.
3. The mortality and morbidity increase in direct proportion to the severity of the pathology.
4. Perforation of the acute gall-bladder with peritonitis has as high an incidence as has peritonitis in acute appendicitis. The

peritonitis does not tend to localize, as is generally believed.

5. Cholelithiasis, present in acute cholecystitis, predisposes toward perforation.

6. Jaundice, regardless of cause, doubles the operative risk in acute cholecystitis. It is usually found in acute disease following upon neglected chronic disease.

7. "Acute on chronic" cholecystitis carries a higher mortality and morbidity than does "acute-first attack" cholecystitis. The mortality in the former is probably proportionate to the severity of the pre-existing chronic disease.

8. Furthermore, the mortality and morbidity of surgery on the acute gall-bladder is directly proportionate to the duration of the acute attack. (This exclusive of cases with acute hemorrhagic pancreatitis.)

9. Immediate surgery, without preoperative preparation, carries a high mortality.

10. "Early" surgery, after a period of preparation has not exceeding twenty-four hours, has the lowest mortality and morbidity.

11. Delayed surgery, after a period of hospitalization of two days or longer, has a mortality rate and a morbidity in direct proportion to the added delay.

12. "Watchful waiting" is a gamble unjustified by the increased morbidity and mortality attendant on delay.

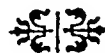
13. The clinical course of the patient gives no index to the pathological severity of the disease.

14. What appears to be an initially successful conservative treatment in acute cholecystitis may finally result in a higher mortality and morbidity for the patients than is found in those operated upon during the acute attack.

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# PERFORATED CHOLECYSTITIS\*

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**S**URGERY on the acute gall-bladder has long been disputed because of a difference of opinion as to the incidence of the severe complications attending this acute abdominal infection. There are, therefore, two opposing methods of treating acute cholecystitis: (1) operating as soon as the diagnosis is made; and (2) observing the course of disease and operating only when intervention is imperative. They arise from a difference of opinion first, as to the incidence of perforation and peritonitis in acute cholecystitis, and second, as to the seriousness of a perforation. The belief has been generally held that perforation was unusual in acute cholecystitis and further that when it occurred localization was the rule.

Eliason and McLaughlin<sup>1</sup> Branch and Zollinger,<sup>2</sup> Smith,<sup>3</sup> Cave,<sup>4</sup> and Pennoyer<sup>5</sup> are but a few of those who believe that perforation either is unusual or generally localizes when it does occur. Saunders,<sup>6</sup> Heuer,<sup>7</sup> Heyd,<sup>8</sup> Stone and Owings,<sup>9</sup> and Walton<sup>10</sup> are among those who have found that perforation, without localization, is frequent in acute cholecystitis. Dependent, then, on these fundamental beliefs is the choice of early surgery, as now practiced in acute appendicitis, or delayed, late surgery as in acute salpingitis.

We are presenting a series of 115 perforations of the gall-bladder encountered in the 3,880 cases of acute and chronic cholecystitis operated on at the New York Post-Graduate Hospital during the years 1920 to July, 1937.

## INCIDENCE OF PERFORATED CHOLECYSTITIS

A résumé of the cases of perforated cholecystitis operated upon in this series is given in Table 1. The incidence in per-

TABLE 1  
THE INCIDENCE OF PERFORATED CHOLECYSTITIS  
(In patients who have recovered from acute attack and are subsequently operated on and the incidence in operated acute cholecystitis.)

Pathology (Microscopic Diagnosis)	No. in Series	Per Cent Perforated	Per Cent Mortality	Morbidity Factor
Chronic cholecystitis (previous acute attack)	474	....	11.2	1.59
"Chronic" perforated cholecystitis.....	46	9.7	19.5	2.20
Acute cholecystitis.....	574	....	10.97	1.55
Acute perforated cholecystitis.....	69	12.1	26.1	2.13
Total cases of perforated cholecystitis..	115	11.0	24.3	2.16

centages, the associated mortality, and the index of severe complications (morbidity factor) are also given. The morbidity factor is determined as follows: A factor of 1 is given each case with a normal convalescence. A factor of 2 is given cases with mild complications. A factor of 3 is given cases with a complication potentially fatal. The means of these equals the "morbidity factor."

The incidence of perforation in all cases operated for cholecystic disease was only 3 per cent. This is not a true index of its frequency for perforation is rare or unknown in true chronic cholecystitis. Therefore the reports from various clinics will differ depending on the type of cases. As a typical instance Judd and Phillips<sup>11</sup> report an incidence of perforation of 0.9 per cent. They recognized the fact that severe acute disease was not generally encountered at the Mayo Clinic. When only the acute cases are considered, together with those with presumptive previous acute

\* From the Combined Medical and Surgical Clinic for Biliary Tract Disease, New York Post-Graduate Medical School and Hospital (Columbia University).



disease, the incidence of perforation is 11 per cent. (Table I.)

#### "CHRONIC" PERFORATED CHOLECYSTITIS

The 46 patients with "chronic" perforated cholecystitis comprising this series were, on the whole, operated on for chronic cholecystitis. They all had both pathologic and historical evidence of previous acute attacks an average of 2.8 months before surgery. It is probable that the perforation, in the vast majority, took place at this time. They are typical of the "hidden perforations" discussed by Touroff<sup>12</sup> and Mitchell.<sup>13</sup> Either perforation was not recognized or the attending peritonitis became self-limited. In general, however, the clinician did not recognize that perforation had taken place.

The conservative treatment of acute cholecystitis is attended by a serious risk of perforation, as is well illustrated in this series of 474 cases with their forty-six perforations. The mortality rate was slightly higher than in operation for acute cholecystitis, in spite of the fact that many of the latter cases represented surgical emergencies. In those cases where perforation and localization had occurred, the mortality rate was 19.5 per cent on subsequent operation, and the morbidity was very high.

Six patients with "chronic" perforations were operated on for bowel obstruction. In each instance the gall-bladder had perforated into the colon, and adhesions, edema, and stones caused the obstruction. In three a cholecystoduodenal fistula existed. Common duct obstruction was found in eighteen cases.

Death in "chronic" perforated cholecystitis was due primarily to peritonitis and "liver death." The first cause is that inherent in the technical difficulties involved in removing a chronic, perforated gall-bladder, especially if a common duct obstruction or the perforation of an adjoining viscus is a complicating factor. The second cause, liver death, is due to the severe liver damage so often found in

neglected cholecystitis. Colp and Ginsberg,<sup>14</sup> in an excellent study of the cause of death following surgical diseases of the biliary tract, found seven patients with a suppurative peritonitis following operations for chronic cholecystitis. They also found a surprising number of deaths in which surgery was not done or where palliative measures only were attempted in moribund patients.

TABLE II  
A CLASSIFICATION OF CASES WITH PERFORATION ON THE  
EXTENT OF THE ASSOCIATED PERITONITIS

Pathology	No. of Cases	Per Cent Mortality	Morbidity
Perforated with abscess (localized).....	16	0.0	2.19
Perforated peritonitis (local and general).....	46	30.5	2.13
Perforated—peritonitis and acute pancreatitis.....	7	71.4	
Total acute perforation.....	69	26.1	2.15

#### ACUTE PERFORATED CHOLECYSTITIS

Twelve per cent of all patients operated upon for pathologically proved acute cholecystitis had perforations. A number of very severe fulminating cases were in this group, including seven of acute suppurative or hemorrhagic pancreatitis. The incidence of perforation generally found in our series is comparable to that in acute appendicitis (Keyes<sup>15</sup>). A brief résumé of the acute perforations encountered in 574 cases of acute cholecystitis is given in Table II.

*Perforation with Abscess.* Only 23 per cent of all proved acute perforations had localized at the time of operation. Stones were present in each instance. It is evident that localization was not the rule in our series. The low incidence of abscess formation cannot be attributed to early surgical interference, for the average pre-hospitalization duration of the acute illness in abscess cases was 9.8 days and in the



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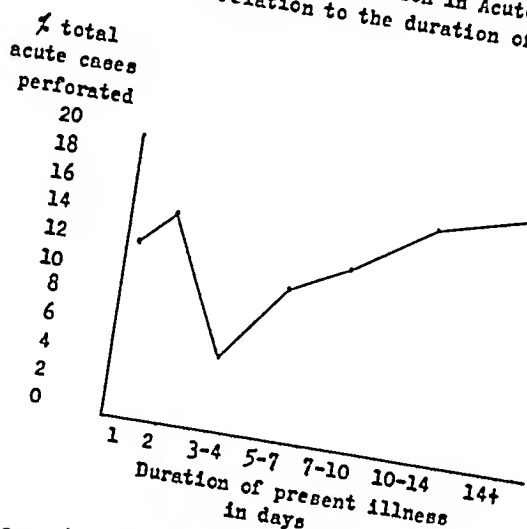
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peritonitis cases was 9.3 days (exclusive of those with pancreatitis).

There were no deaths among those

operation. Sixty per cent had a diffuse or generalized peritonitis, while in the remainder inflammation was localized by the

GRAPH I Incidence of Perforation in Acute Cholecystitis in relation to the duration of the P.I.



operated on for an abscess in spite of the fact that cholecystectomy was done in fifteen of the sixteen cases. It is probable that the cause for the success in these cases lies in the cause for localization, i.e., the low virulence of the organisms involved. The morbidity was very high. Ileus, thrombophlebitis, pneumonia, and wound infection were responsible for most of the severe complications.

**Perforation with Peritonitis.** Fifty-three patients, or 77 per cent of all cases with perforation, had peritonitis at the time of

omentum and colon. This high incidence of peritonitis in acute perforation is substantiated by the findings of Heuer,<sup>7</sup> Boyce, Veal and McFetridge,<sup>16</sup> Pratt,<sup>17</sup> Glenn,<sup>18</sup> and others. The continual menace of a diffuse peritonitis in acute cholecystitis is thus apparent. McClure and Altemeier,<sup>19</sup> in a recent comprehensive report on perforated appendicitis, found peritonitis in only 53 per cent. Comparatively speaking, the danger of a diffuse peritonitis, as seen in our series, is as great in acute cholecystitis as that generally reported in acute appendicitis.

Were the patients operated upon too early? Would localization have followed, if more time had been allowed? These questions are partially answered in Graph I which shows the incidence of perforated cholecystitis among the total cases of acute cholecystitis in which operation was done. Only the cases with a reliable history are included. There is a high incidence of perforation during the first two days of illness; it then drops and increases again in proportion to the delay in operating. Perforation occurred as late as fifty days after the onset of the acute symptoms, although in the majority of cases it was

TABLE III  
ANALYSIS OF SIXTY CASES OF ACUTE PERFORATED CHOLECYSTITIS ON THE BASIS OF THE TIME OF OPERATION

Perforated Cholecystitis (Pathology)	No. of Cases	Duration of Present Illness (before Admission)	Time in Hospital (before Operation)
With abscess (localized).	13	9.8 days (3-21 days*)	1.7 days (1 hr-6 days*)
Peritonitis secondary to rupture abscess.	10	16.1 days (2-50 days*)	3.3 days (2 hrs-13 days*)
Primary peritonitis (direct perforation).	30	6.9 days (2 hrs-26 days*)	1.2 days (2 hrs-6 days*)
Peritonitis complicated by severe pancreatitis.	7	2.2 days (12 hrs-5 days)	16 hours (1 hr-3 days*)

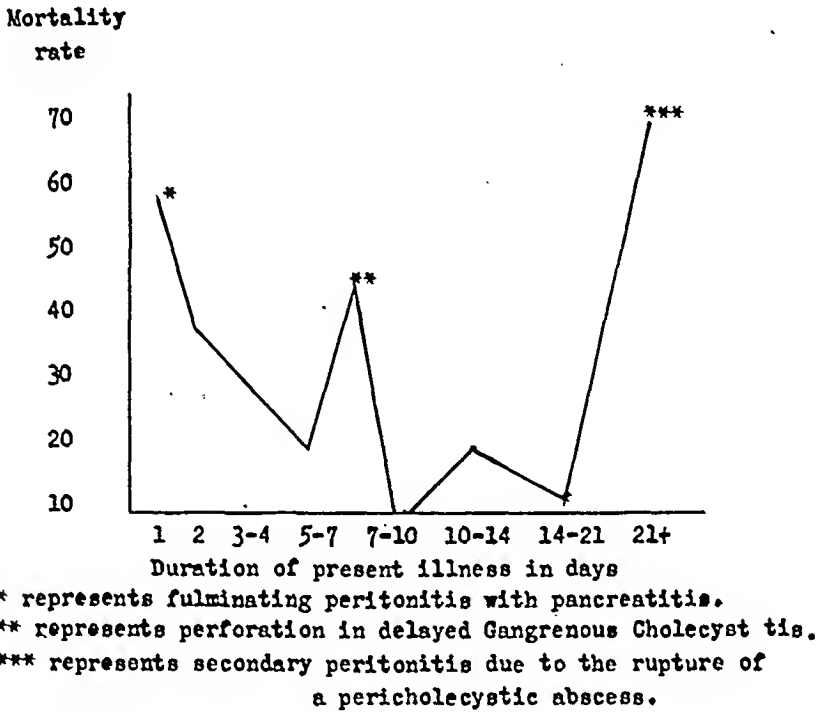
\* Figures in parentheses represent the extremes in time element.

seen between three and seven days after the onset.

to a further average delay of 3.3 days before they came to operation. The cause of death is readily apparent; the four

Table III cites the pertinent data on the

GRAPH II Mortality rate in Perforated Cholecystitis on the basis of the pre-operative present illness.



immediate illness of patients operated on with perforations, and Table IV the data on their mortality.

TABLE IV INFLUENCE OF DELAY IN SURGERY ON THE MORTALITY IN PERFORATED CHOLECYSTITIS (COMPARE WITH TABLE III)

Perforated Cholecystitis (Pathology)	No. of Deaths	Average Duration Present Illness	Average Time in Hospital	Per Cent Mortality
With abscess (localized)...	0	.....	.....	0.0
Peritonitis secondary to rupture of abscess.....	4	27 days	6.5 days	40.0
Primary peritonitis (direct perforation) .....	10	7.5 days	1.4 days	33.3
Peritonitis complicated by severe pancreatitis.....	5	2.6 days	24 hours	71.4

The ten cases of peritonitis due to the secondary rupture of a previously localized abscess are of great interest. Delay in recognizing or draining a pericholecystic abscess was attended by a mortality of 40 per cent. These patients were admitted on an average of 16.1 days after the onset of their acute symptoms and subjected

individuals who died were even longer delayed before they came to operation (total of thirty-four days). This would appear to be reliable evidence against the teaching of "watchful waiting," for had localization been suspected these patients would have been operated upon earlier. The "late peak" in mortality, shown in Graph II illustrates this danger.

The thirty cases with peritonitis from direct perforation of the gall-bladder had an average pre-hospitalization illness of 6.9 days and were observed 1.2 days. The mortality rate of 33.3 per cent is that generally reported for peritonitis in acute abdominal disease. Boyce et al.,<sup>16</sup> Liedberg,<sup>20</sup> Mentzer,<sup>21</sup> and others report a similar mortality. Glenn,<sup>18</sup> Heuer,<sup>7</sup> and Wolfson and Rothenberg<sup>24</sup> had a much lower mortality in acute perforated cholecystitis with earlier operation. This group of perforations occurred in neglected acute gangrenous cholecystitis.

The fourth group of perforated cholecystitis is that in which perforation

occurred associated with an acute suppurative or hemorrhagic pancreatitis. Little has been said of this highly fatal complication in the literature, but the cases in our series were definitely associated with a neglected chronic cholecystic disease and usually with common duct involvement. The early high incidence of perforation seen in Graph II is due to these cases. To determine whether or not an acute gall-bladder will perforate is as difficult as answering the same question in acute appendicitis. Touroff,<sup>12</sup> Heuer,<sup>7</sup> and Mitchell<sup>13</sup> have shown that there is little parallelism between the patient's clinical course and the pathologic progress of his acute infection. Forty-six of the perforations were observed in the hospital for twenty-four hours or more. Eleven of these did not appear to be progressive from a clinical standpoint, and yet they had a peritonitis. Four of these were localized and seven diffuse.

**Cause of Death.** There were nineteen deaths in this series of acute perforations. Table v is a summary of the causes of death and the time of death in relation to operation. Peritonitis was the cause of death directly or indirectly in two-thirds of the cases.

TABLE V  
THE CAUSE AND TIME OF DEATH IN ACUTE PERFORATED  
CHOLECYSTITIS

Cause of Death	No. of Deaths	Time of Death (Days Post-operative)
Liver death.....	5	23 hours
Peritonitis.....	6	6.5 days
Peritonitis and pneumonia...	3	7.0 days
Peritonitis and secondary hemorrhage.....	1	
Pulmonary embolism.....	3	22 days
Uremia.....	1	13 days
		16 days

### CONCLUSIONS

1. Perforation of the gall-bladder during an acute attack is as frequent and as fatal from a statistical review as that in acute

2. Perforated cholecystitis in our cases did not localize as frequently as has been reported in other series.

3. Perforation, other than that associated with a marked fulminating infection, was found when there was neglect in operating for chronic cholecystitis and delay in operating for acute cholecystitis.

4. The highest mortality in perforated cholecystitis was found in those patients with (1) pancreatitis, 71.4 per cent; (2) neglected acute gangrenous cholecystitis, 45 per cent; and (3) a perforation of a neglected pericholecystic abscess, 40 per cent.

5. A study of the clinical course and pathologic findings presented by those patients who recovered and those who died, reveals, as has been shown in other series, that "watchful waiting" is not a safe method because of the lack of parallelism between the clinical course of the disease and its pathologic progress.

6. We believe that when the high incidence of perforation and the dangers inherent in peritonitis due to acute cholecystitis are recognized, early surgery will become the general method of treatment.

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